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ASSAULT GLIDERS: A REEXAMINATION

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

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B.A., Auburn University, Auburn, Alabama, 1985

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This is a critical examination of the combat glider as used in World War II. This study uses the Market-Garden airborne invasion of Holland in 1944 to determine whether the glider was cost effective as a system of airborne assault.

Cost effectiveness is determined by comparing glider echelons with parachute echelons. Five elements of cost contribute to the expense of airborne operations. These elements are equipment costs, training costs, assembly-packing costs, pay costs, and recovery costs. A Standard Unit Equivalent (SUE) provides the common denominator for capability of gliders and parachutes. SUEs measure combat capability and produce a resultant dollar amount. The more cost effective force is the echelon with the least cost for the same combat capability on the ground.

Gliders, as used on the first day of the Market-Garden airborne operation were not cost effective because of high costs, poor recovery, and less combat power delivered compared to the parachute. A cost effective successful glider model is offered as having value to any consideration for future glider use.

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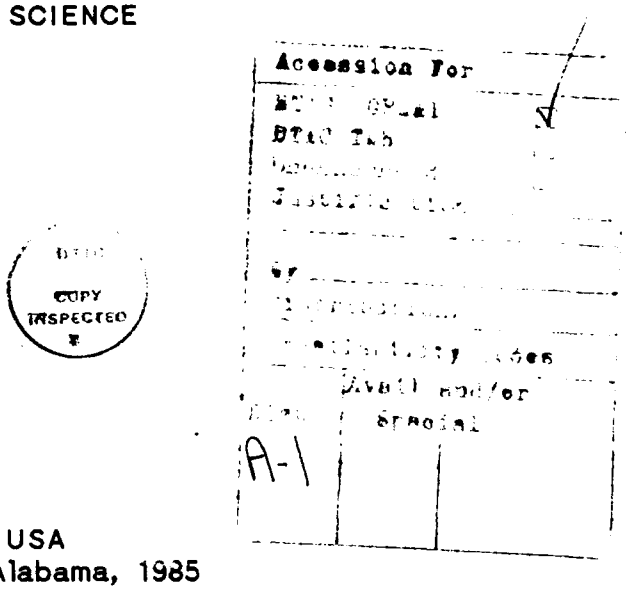

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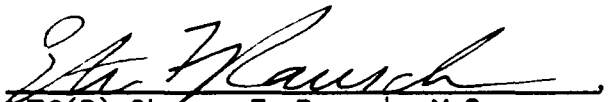
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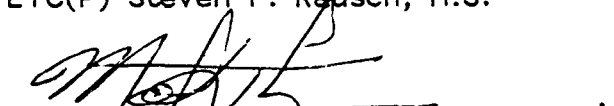
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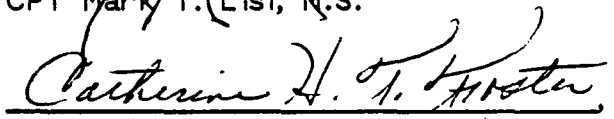
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ABSTRACT

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This is a critical examination of the combat glider as used in World War II. This study uses the Market-Garden airborne invasion of Holland in 1944 to determine whether the glider was cost effective as a system of airborne assault.

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ACKNOWLEDGMENTS

Major Edwin C. Parrish III kept a small model of a glider on his desk when I served as a platoon leader for him in Task Force 160. Not far from this model glider, one of the four known remaining CG-4A gliders sat inside Fort Campbell's post museum. Both gliders captured the character of Parrish and the unit we served in--- exceptional, expedient, and experimental. That unit taught me to continually apply new ideas to standard ways of doing things. This reexamination of the glider does the same thing with an aircraft I've always been curious about. My curiosity would have remained unanswered except for learning how to look at problems differently in Parrish's unit. For that experience, I'm grateful.

I'm also grateful to many others who have helped me in this project. These people are my wife, for her patience and support, Major Brian "B.D." d'Autremont, for introducing me to the personal computer and its cost effectiveness, and the exceptional staff of the Combined Arms Research Library who with such dedicated people as Mr. Craig Mclean made this easier.

Of course, I want to thank the handful of glider pilots, many authors themselves, who gave me the missing links to my research. To their dedication and wartime courage, I give my highest respect.

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It is well to remember two things: no weapon is obsolete, and the second of even greater import--- no weapon, whose potential is once recognized as of any degree of value, ever becomes obsolete.

J.M. CAMERON

The National World War II Glider Pilots Association coat of arms was designed by the US Army Institute of Heraldry. The shield in the center is air force blue with eight stars at the top denoting the number of World War II campaigns in which gliders were used for combat assaults, rescue operations, and resupply attempts. The single star at the base of the shield represents the five Army Air Forces to which gliders were assigned. The scarlet globe in the center symbolized the worldwide conflict of World War II, and its two sections allude to the glider's employment in both the northern latitudes of Europe and the southern latitudes of the Pacific. The silhouetted glider shown is a Waco CG-4A seemingly in flight against a background of sky and clouds. Silent Wings Museum.

CHAPTER ONE

INTRODUCTION TO ASSAULT GLIDERS

Defining The Research Problem

Gliders served as an airborne assault system on a mammoth scale. The scope of these operations however, occurred during a brief period when viewed across the expanse of airpower's contributions to military tactics and doctrine. The assault glider, as defined in this thesis, enjoyed a robust, albeit brief, life. This lifespan dawned following the start of World War II. For the United States, gliders rolled off assembly lines to rank as the third most produced combat aircraft of the war behind the B-24 bomber and P-51 fighter.[1] Following the end of the war, gliders remained an operational technique for airborne units. The last doctrinal mention of assault gliders was in 1952. The Army's Airborne Techniques for Divisional Units field manual referred to assault transports employed without engines as gliders.[2]

At the time, powered assault transport aircraft and the successful combat airdrop in Korea of troops and heavy equipment edged the glider out of the airborne arsenal. Perhaps the glider's demise was premature when viewed against the competing technologies of the assault transport and parachute delivery of heavy equipment, neither having enjoyed success in World War II. The newly created United States Air Force committed itself to fielding a durable short take-off and landing tactical powered aircraft to support the Army. The aircraft it picked had

durability, payload, and the short landing characteristics the Army needed. By no coincidence, the aircraft was a glider with engines. The CG-2ØA glider, developed during World War II, became the C-123 assault transport.[3] With equal vigor, the Army pressed for the capability to deliver heavy equipment by parachute.

The heavy-drop technique of using cargo parachutes to deliver artillery, vehicles, and some armored equipment was virtually perfected. Many airborne enthusiasts however, argued that limitations in accuracy, payload, and the time required to configure heavy loads proved far less a panacea for parachute forces than originally envisioned. The same is true of the assault transport. The C-123 is obsolete in the active force and its replacement, the C-13Ø, although a workhorse, requires relatively prepared surfaces for operation. What then, of the glider as used in World War II?

Would an assault glider offer any increase in capability today? Perhaps technology and tactics have advanced enough to overcome the limitations causing the death of the glider. This study answers these concerns through the window of cost effectiveness. Cost effectiveness is traditionally one measure of the success or failure of a piece of equipment or system. This study goes beyond a simple cost effectiveness review however, by selecting as a model for study an actual combat airborne operation. This model, limited to the first day of the largest airborne assault in history, provides the framework for this study.

The Research Question

Were gliders cost effective compared to the use of parachutes as a means of airborne assault on the first day of the Market-Garden operation?

Background to the Research Question

During World War II, gliders flew on a scale never seen before with the United States Army's plans to build 36,ØØØ gliders.[4] The scope of the glider's use was planned to exceed the use of parachutes. Each of the Army's airborne divisions initially owned two glider regiments and one parachute regiment, but this changed to two parachute regiments and one glider regiment when staff officers discovered that not enough cargo space existed for the troopships moving overseas if the airborne division packed its gliders. In the interest of economy, one glider regiment in each airborne division was converted to a parachute regiment with the stroke of a pen.[5] Fortunately, the airborne training pipeline readily provided enough parachute qualified soldiers for the change. Cost effectiveness issues would continue to affect the Army's glider program however. This study uses the Market-Garden operation as the laboratory to study the cost effectiveness of the glider. Market-Garden was selected for several reasons.

First, Market-Garden was the largest airborne operation of all time. The operation, over its course, inserted by parachute and glider, more than three divisions behind enemy lines. The operation planned for both glider and parachute echelons to land on drop zones and landing zones in similar terrain. Although the tactics and strategy of the Market operation have been argued over the years, the first day, as an

airborne operation was an unqualified success.[6] As shown in Figure 1-1, the number of gliders employed on the first day of the Market airborne operation provides a large sample from which glider use may be examined.

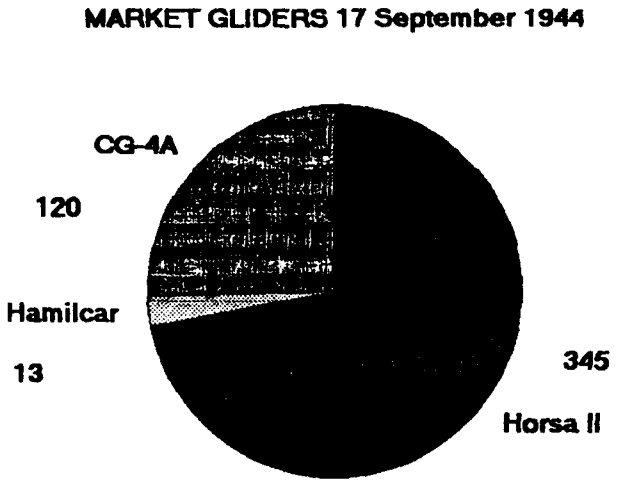


Figure 1-1. Number of gliders employed on 17 September 1944 in Market operation. Number obtained from U.S. War Department, Report of Airborne Phase, Operation Market, 18th Airborne Corps, 17-27 September 1944.

Second, Market was a combined operation. The first day, 17 September 1944, saw the combined airborne assault of the First British Airborne Division, the United States 82nd and 101st Airborne Divisions, and the corresponding airborne corps headquarters with these divisions. In assessing the cost effectiveness of the glider, the British use along with the United States' employment on the same operation provides an unparalleled model for study not found elsewhere in the war.

Third, and most important if this study holds any lessons for the future, is that Market occurred relatively late in the war. By the summer of 1944, airborne doctrine had matured to a state of confidence by both the troop carrier units and the airborne units. Unlike many earlier fumbled attempts at airborne assault, Market was the result of valuable combat experience. As such, Market gives this study the combat laboratory needed to assess cost effectiveness.

Several assumptions are required to establish the framework for this reexamination of the assault glider.

Assumptions Required of This Study

1. The Market airborne operation, specifically the first day, is the correct sample population for this cost effectiveness study. Only an actual combat operation would provide the credible scenario, or laboratory, for this study. The hazard in selecting only one operation for study however, is that perhaps the selection is of the wrong battle. The assumption is that Market best represents a large-scale, successful airborne operation and as such will provide the accurate model for study.

2. This study's use of the Standard Unit Equivalent (SUE) to determine the value of a glider's cargo in relation to a parachute delivered rifle squad is a fair assessment of glider capability for delivering combat power to the battlefield.

3. The five cost elements used to determine the cost effectiveness of the glider accurately represent the major costs of using gliders on the first

day of Market. These cost elements are assumed to have value when applied to any other study of the glider.

4. This study assumes all dollar figures as correct and accurate assessments of costs. A three dimensional verification was performed on all dollar amounts. First, every dollar figure was confirmed from a primary source where possible. Second, dollar figures were confirmed by subject matter experts, and these experts are noted in this study. Finally, the author applied subjective experience to the dollar figures to be sure they were applicable. Where actual amounts were not available, it is noted in this study, and a close approximate is made.

Definition of Terms

1. Assault glider. The assault glider is a powerless aircraft of conventional design with inherent flight characteristics of powered aircraft. It is dependent upon powered aircraft for movement through the medium of a tow rope. When released for free flight from any altitude, its relatively low wing loading gives it a high gliding ratio and a comparatively low landing speed. The successful employment of the glider is in direct proportion to the quality of the pilot.[7] During World War II, United States gliders were classed as Cargo Gliders, hence the designation "CG." The assault glider, as developed during the war, was a squad carrying, heavily armed glider that never made it off the drawing boards. For this study however, all gliders are called assault gliders because of the way they were employed. Gliders in this study flew in direct assault upon enemy-held terrain. The accurate term is assault glider and is used in this study.

2. Parachute troops (parachutists). Those troops delivered to the combat area by transport aircraft upon arrival who will jump from the aircraft in flight and conduct a parachute descent into battle.

3. Personnel parachute. The personnel parachute was designed to carry one paratroop and his individual equipment into battle. The standard U.S. personnel parachute for Market was the T-7. The standard British personnel parachute during Market was the X-type.

4. Landing Zone (LZ). An area of terrain, upon which, gliders will land. The ideal LZ would be relatively flat, free of obstacles, generally level, and large enough in size to support the number of gliders anticipated to land there.

5. Drop Zone (DZ). An area of terrain, upon which paratroops will land. The ideal DZ would be relatively flat, free of obstacles, and large enough in size to support the number of jumpers anticipated to land there. Considerations for both the drop zone and landing zone are similar. The chief difference is that a drop zone must consider the dispersion of the jumpers and speed of the aircraft as it passes over the drop zone. A landing zone for the gliders must consider the ground run of the glider and the number of gliders expected to use the landing zone.

The limitation of the parachute is that a large number of jumpers requires a large area. Even with current technology, a single parachutist requires an area 300 meters X 300 meters.[8] This figure is for peacetime safety concerns. The glider also required a large area for training, but in combat these dimensions were reduced.

6. Glider troops. Troops whose primary means of insertion into battle was by glider. Glider troops did not initially receive the pay or special uniforms that their paratroop comrades received. Although authorized by the time of Market, those glider troops participating in Market did not receive glider pay for that operation.

7. Tow and tug. These terms are interchangeable. The cargo aircraft, usually a C-47 aircraft, having the mission to tow a glider to its release point near the LZ was called a tug. The act of pulling a glider behind a tug was called towing. During World War II, a variety of different types of aircraft were used to "tow" a glider. A most novel concept was that of using a P-38 fighter aircraft to tow a glider by the P-38's bomb shackle. The P-38 could then release the glider over its LZ and the P-38 could provide fighter cover until the glider landed. This concept would have had remarkable cost effectiveness implications if it had been employed.

8. Tow rope. A 300-foot nylon rope used to pull a glider behind a tug. Other lengths of rope were sometimes used, but the 300-foot length was standard for the Market operation. The British gliders used a Y-shaped rope of shorter length usually 150-feet long. The tow rope deserves mention because it limited the glider's effectiveness. Several gliders would not make it to Market because of broken tow ropes. Tow ropes frequently became overloaded or overstressed causing the rope to break. The normal position of the glider was to fly slightly above and behind the tow plane with slack in the tow rope. Normally, a wire communication cable would be wrapped around the tow rope for communication with the tow plane.

The Germans eventually solved the tow rope problem by developing a rigid tow-bar. The rigid tow-bar, although requiring a longer time for the marshalling and attachment to its glider, prevented most of the problems associated with the tow rope.

9. Market-Garden. Market-Garden was actually two operations. Market was the airborne assault to seize a narrow corridor in Holland, through which, armored forces would attack. Garden was the ground armor linkup and attack phase. In execution, Market-Garden became badly overextended, outnumbered by enemy forces, and did not meet its objectives. While the tactical failure to follow-up on the initial success of the airborne assault and the failure of the British 30th Armor Corps to effect linkup raises serious questions, they are not the focus of this study. Suffice it to record that the first day, 17 September 1944, was a successful multi-division airborne assault.

10. Cost. Costs in this study applies to five cost elements of glider and parachute operations associated with the first day of Market. Each of these five costs are described in detail in Chapter Three, but will be briefly mentioned here.

a. Equipment costs. This refers to the capital equipment costs needed to outfit the glider and parachute echelons of the three participating airborne divisions. Specifically, this element refers to the glider and personnel parachute end-item costs.

b. Training costs. This cost is a relative value of the training needed to produce a qualified glider pilot for the glider echelons and the costs to produce a qualified paratroop.

c. Packing-Assembly. This cost element applies to the man-hours needed to pack personnel parachutes for the parachute echelons and the man-hours needed to assemble gliders for the glider echelons.

d. Pay. Pay costs applied to two distinct elements of paying soldiers associated with airborne operations. For this study, pay for the glider echelons only applies to the base and flight pay of the participating glider pilots. Pay for the paratroopers applies only to the jump pay for the participating paratroops.

e. Recovery. This element of costs is the most critical to this study and most difficult to understand. Basically, every glider not salvaged from the Market operation was a glider that had to be replaced. Similarly, every parachute lost or abandoned was a parachute that had to be replaced. Recovery costs in this study assume that gliders and parachutes not recovered had to be procured again at the same costs used for initial equipping of the parachute and glider echelons.

11. Standard Unit Equivalent (SUE). This is the result of a formula to establish a relationship between costs of using gliders versus the costs of using parachutes. SUE is expressed as a number. It is a value in relation to the 12-man infantry squad for the U.S. forces, and the 11-man infantry squad in the British airborne forces. The SUE is the result of this study's requirement to provide an accurate comparison between what a glider can do compared to what a parachute can do. The SUE assigns a numerical value to the payloads of the gliders and troop carrier aircraft. It provides the common denominator link for comparison between the glider and parachute.

Limitations of the Study

This study is limited to the first day of Market, 17 September 1944. This single day of operations was not the largest airborne mission, but it was the most successful of the Market operation. This study is limited to the first day because the first day went almost totally according to plan. The subsequent days were plagued by poor weather and the enemy reaction to the operational surprise afforded by the success on 17 September.

This study further limits its reexamination of the glider to the selected cost elements. In evaluating any weapon or system, many factors may be used to determine the contributions of the weapon or system. Cost is traditionally one sure measure to determine the value of military hardware. Cost effectiveness evaluations are part of all development processes in the military. If this study is to have future application, then the costs of employing gliders must be considered.

Delimitations of the Study

This study will not include other costs besides the five elements of cost as defined in this chapter. This is both a deliberate and conscious decision to focus strictly on the significant outstanding costs of conducting the airborne portion on the first day of Market. The main reason many costs were left out is because in comparing the parachute and glider echelons, some costs cancelled each other out. For example, whether a infantryman rode to battle via parachute or glider, he still received his base pay. What was unique about his base pay in the case

of the paratrooper is that it was boosted by an additional $5Ø per month jump pay. The glider soldier did not get this, so the jump pay becomes a cost element.

Another significant cost was involved in transporting all the gliders to England. Once in England, gliders had to be assembled and transported to their respective staging bases. The troop carrier planes whose mission was to drop paratroopers simply had to fly to the correct marshalling area and load the jumpers. While the costs of assembly of gliders was significant enough to include, the other transport costs were not. Many of these types of cost elements were inappropriate for this study and were not included.

Leadership's impact on the effectiveness of glider and parachute units cannot be discounted. The yardstick for the success of leadership is mission accomplishment. Accordingly, both glider and parachute units were highly successful, and both were at various times misemployed, misunderstood, and misguided. The author's review of the history of glider and parachute units uncovered many brave deeds, many heros, and individuals with a strong sense of mission for both the glider and parachute units. Senior leadership's vision for the organization is the name for this infusion of spark, guidance, and support. For this study, it was recognized that divergent leadership objectives existed for both glider and parachute units. They will not be included here.

Some measure of background is needed to understand this study's approach to the cost effectiveness problem. For each of the five elements of cost, a brief introduction to the elements is included here to bring the reader to the necessary level of understanding for this study

to proceed. This background will assist in understanding the nature of the glider and parachute costs involved in this study and reasons for their selection for inclusion.

Background to the Cost Elements

Equipping the Airborne Force

The United States Glider Program

Germany provides the backdrop to the United States glider program. The German's initial success with assault gliders sparked the United States program. Germany's program however, was born of its defeat in World War I. Following that war, the defeated Germans began building their air force for use in World War II.

The Treaty of Versailles prevented the Germans from developing powered aircraft for military use. The Germans however, already sport glider enthusiasts, began toying with the idea of gliders for military applications. Since the Germans, by treaty, could not build more expensive forms of aircraft, the glider offered them in the prewar years an economical alternative to more expensive forms of aircraft as well as providing an excellent training tool for pilots.[9]

The German pioneering effort with assault gliders resulted from constraints following its defeat in World War I. Germany prior to World War II had 186,000 licensed glider pilots compared to only 384 licensed glider pilots in the United States. The glider's advantage however, as a combat and cost effective aircraft would wait until its first successful use in combat. The Germans' assault on Belgium in the early days of World War II would demonstrate the glider's success.

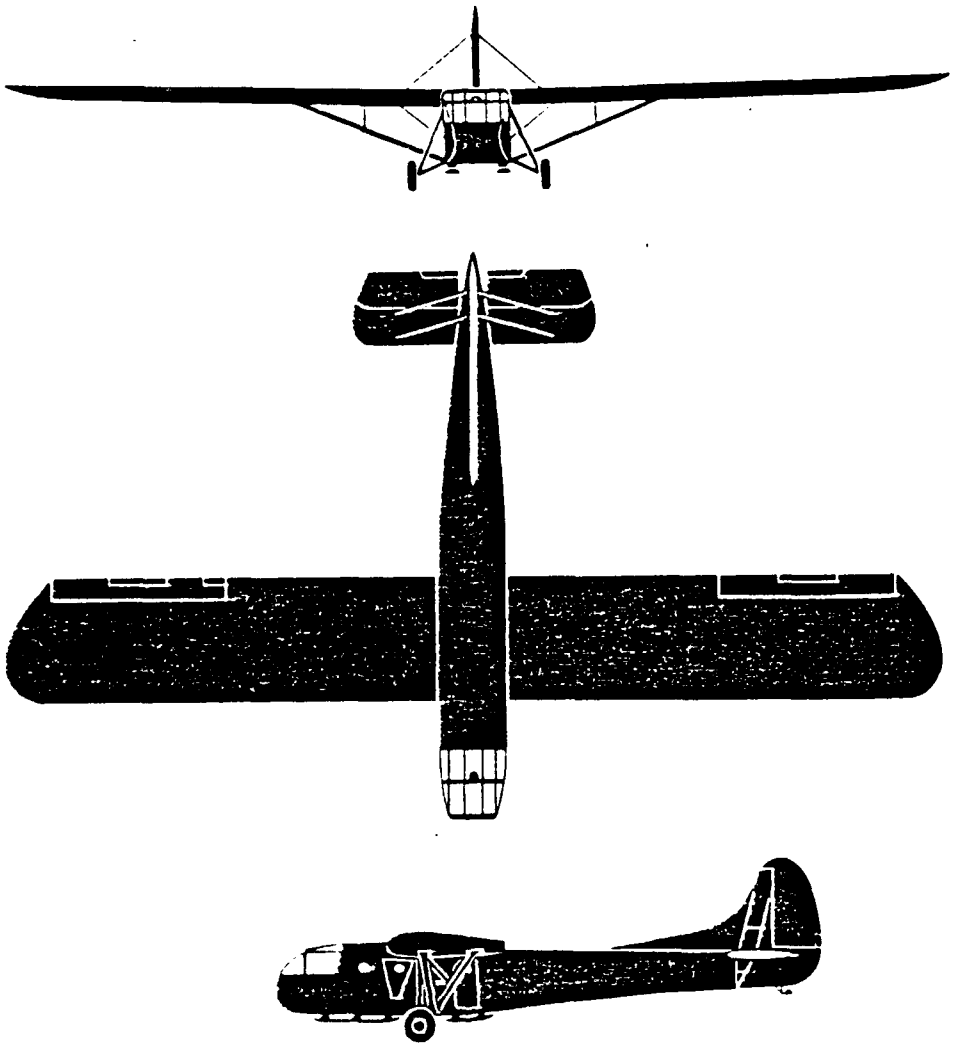
The first assault glider to slip on silent wings in combat flew during the German's successful assault on the Belgian fortress of Eben Emael in 1940 when the Nazi invasion swept across the Low Countries. This well-rehearsed assault by a small group of German glider-borne troops sparked a race for gliders among the allies. The United States and Britain, shocked by the swift, silent, and stunning Eben Emael assault launched a rapid program to develop gliders. United States planners however, could not have known in 1940 that the first U.S. glider assault in combat was still more than two years away. Consequently, the U.S. began its glider program at a pace preventing any detailed research and development normally associated with new aircraft. The urgency of the program resulted in cost overruns and unguided direction. The race was to put gliders in the hands of troops for training as soon as possible.

In February of 1941, U.S. Army Air Corps General Henry H. "Hap" Arnold directed the start of the glider program. Many different manufacturers acted on the opportunity to make gliders for the Army. Besides aircraft companies, many unlikely candidates for the production of combat aircraft signed up for glider contracts. Furniture factories, piano companies, a casket maker, and a pickle company entered the glider business to produce CG-4A gliders from common plans.[10]

Almost 16,000 gliders rolled of assembly lines in the United States during World War II. Most were the CG-4A glider. (See Illustration One.) This glider is commonly called the Waco. Waco made 999 CG-4A gliders,

ILLUSTRATION ONE

CG-4A GLIDER



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only a small portion of the total, but as the Waco Aircraft Company of Troy, Ohio delivered the first, the name Waco stuck. Most references to the CG-4A use the term "Waco" to describe the CG-4A, but Waco was the fourth largest maker of the CG-4A.

The CG-4A designation refers to "Cargo Glider," production model 4. The Army shipped 5,991 CG-4As to the European Theater of Operations (ETO). Other types were the CG-15A, a total of eighty-seven shipped to the ETO, and eighty-one CG-13As, also in the ETO. Although both of these gliders were more capable and available during Market, the literature failed to disclose why these were not used in Market.

Glider procurement involved twenty-three companies in ten states for the experimental models and twenty-two companies in fourteen states for the production models. Almost $500 million was spent in the program.[11] No quality control measures watched the first production gliders. Cost per glider ranged from $15,000 to $1.7 million.[12] The production rates had never been attempted before, even by experienced aircraft companies. As an example of some faulty manufacturing, a tragic accident involving a St. Louis glider contractor killed the mayor of St. Louis, the president of the Robertson Aircraft Corporation and other officials during a demonstration flight. An investigation revealed a defective strut brace. This negative testimony to the reliability of gliders would plague the program throughout the war.[13]

The haste of the glider program and the urgency to begin training of airborne units resulted in the uncoordinated purchase of gliders. Table 1-1 shows the various makers of the CG-4A.

TABLE 1-1.--CG-4A PRODUCTION DATA

Contractor	Average Cost	Delivered
Ford	$14,891	2,418
Waco	$19,367	999
Gibson	$25,785	1,Ø55
Commonwealth	$24,232	95Ø
Northwestern	$24,543	887
G & A	$25,144	464
General	$31,Ø1Ø	1,Ø13
Ridgefield	$38,2Ø9	155
Robertson	$39,Ø27	147
Pratt, Read	$3Ø,8Ø2	925
Laister-Kauffmann	$29,437	21Ø
Cessna	$3Ø,324	75Ø
Babcock	$5Ø,9Ø6	6Ø
Timm	$51,123	433
Ward	$379,457	7
National	$1,741,8Ø9	1

Source: James E. Mrazek, Fighting Gliders of World War II (New York: St. Martin's Press, 1977), Appendix III.

The British Glider Program

The British Horsa glider has been called the "ugly duckling" of World War II gliders and was the mainstay of the British glider force during the war. It was designed with the intent of saving critical metals

by drawing upon woodworking industries not involved in war production. A specification was issued to the Airspeed Aviation Company, Limited at Portsmouth for the Horsa. The first production Horsa flew in September of 1941, only nine months after the initial specification was issued.[14] (See Illustration Two.)

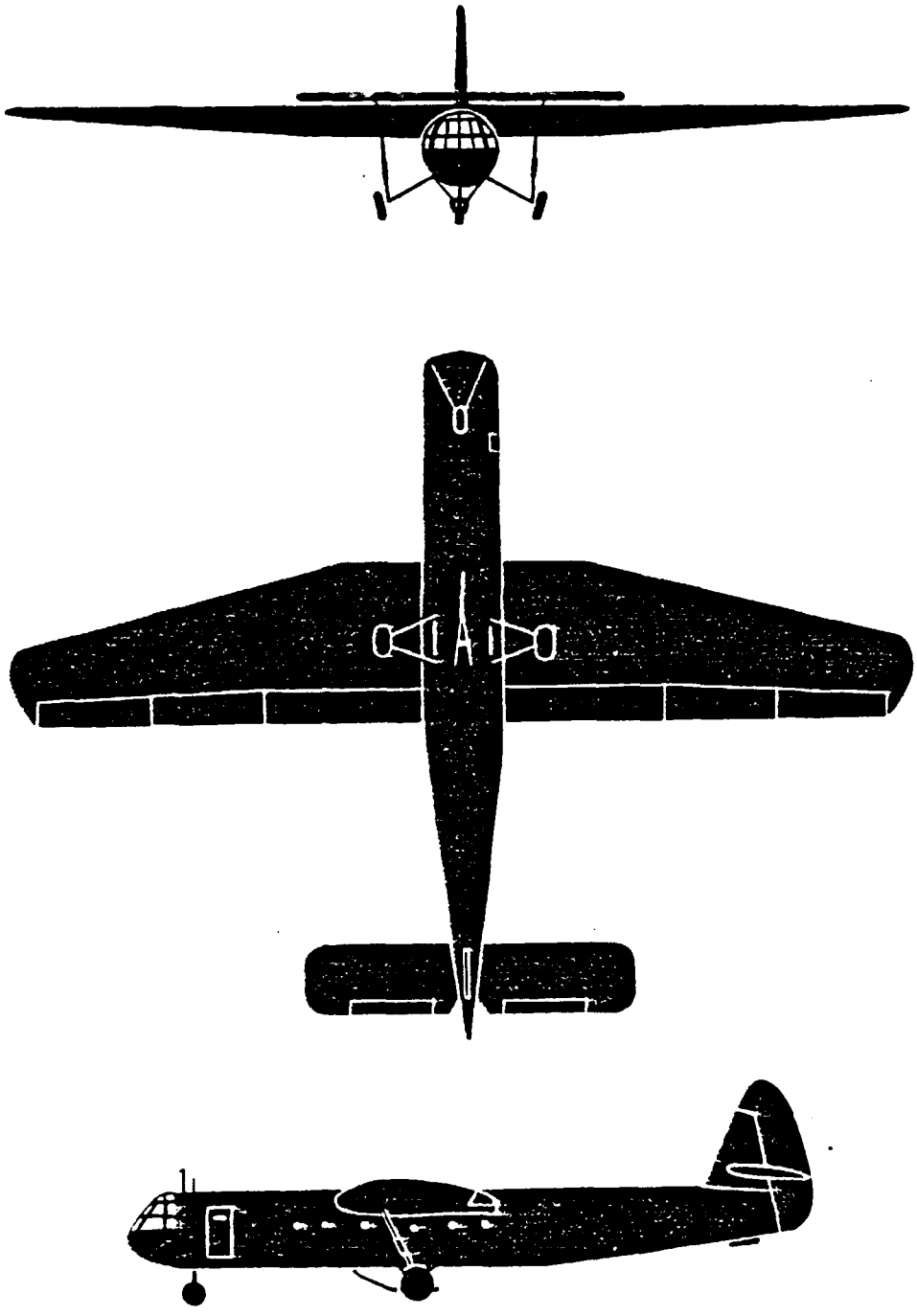
The first prototype Horsas were completed at Salisbury Hall, London Colney, and then assembled at Fairey's Great West Aerodrome. Remaining prototypes were assembled and test flown at Portsmouth under trials with combat equipment.[15]

The plan for Horsa production was for woodworking factories to produce the Horsa in sections. It would then be assembled and test flown by Royal Air Force (RAF) maintenance units. Almost 3,000 Horsas were made this way with another 700 being entirely constructed, assembled, and test flown at the Airspeed factory at Hampshire.[16] The Horsa went into full production following the allied invasion of Sicily in 1943. Test flights in the Horsa were recorded up to an altitude of 20,000 feet.[17]

The Horsa was made largely of wood. Examination of its cockpit revealed great woodworker skill. Dual controls with air-brake control levers, tow-release, and trimming wheels were of wood. [18] The main landing gear could be jettisoned. If jettisoned, a nose wheel and shock-absorbing skid took over.

Both the Mark I and Mark II Horsa were similar in appearance. The Horsa was a high-wing monoplane. It had an eighty-eight foot wingspan and a fuselage length of sixty-seven feet. At the top of its tail, it was more than twenty feet tall.

ILLUSTRATION TWO
AIRSPEED HORSA II



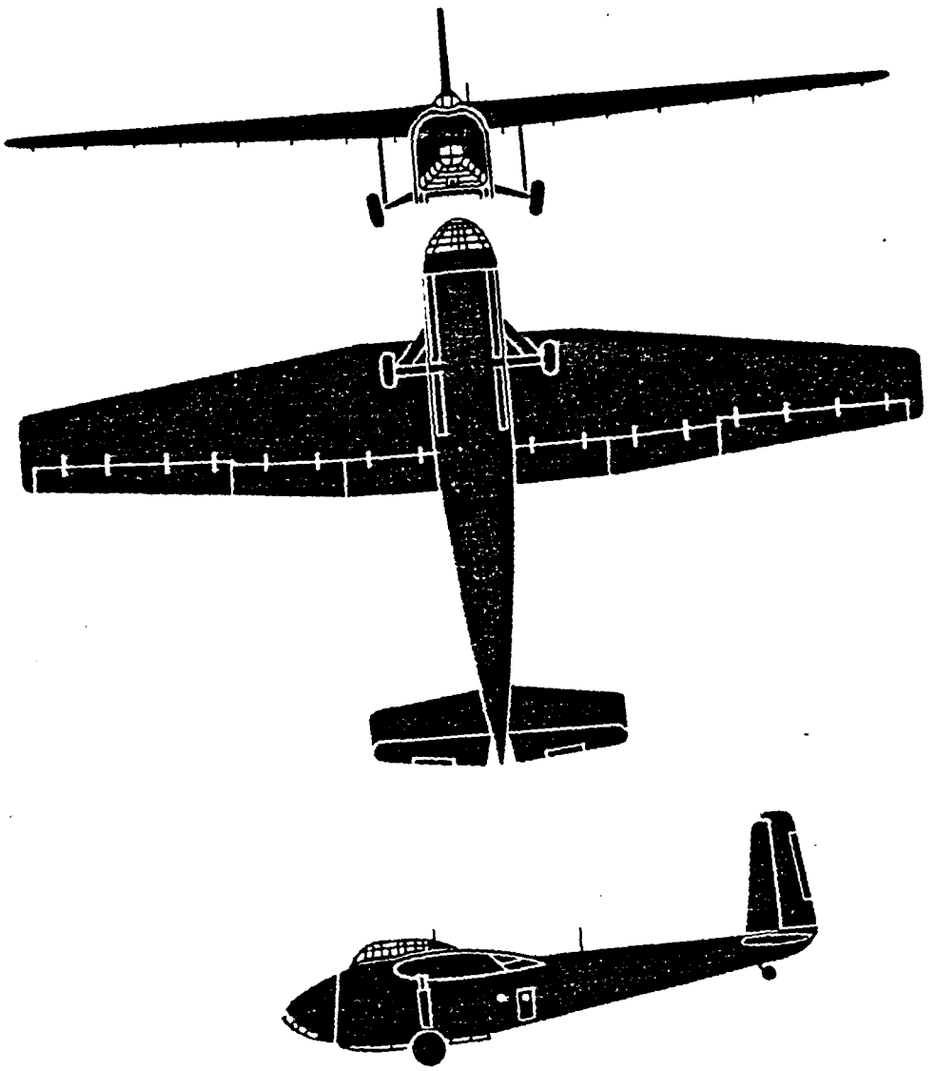
Reprinted, by permission, James E. Mrazek, Fighting Gliders of World War II, (New York: St. Martin's Press, 1977), 71.

Designed to be towed over a drop zone and for parachutists to jump from the glider, the Horsa had two jump doors and firing ports for the parachutists to shoot at attacking planes. A loading door was at the left front of the Horsa. A jeep could be maneuvered around this door onto the cargo floor. Upon landing, troopers would either cut or blow the tail off the glider for unloading. Because of the need to recover gliders for future operations however, the Horsa II used a hinged nose similar to the CG-4A for less destructive unloading.

The Mark II Horsa carried twenty-eight troops, a pilot and copilot. Instead of all troops, the Horsa could carry two jeeps, or a 75mm howitzer and a jeep, or a cargo load of 7,380 pounds. The Horsa used a Y-shaped tow rope. The tow position was above and behind the tug, and the Horsa could be towed at a maximum speed of 160 knots. The Horsa had a stall speed of fifty-eight knots and a glide aspect of 7.2:1. The Horsa's primary tow aircraft were the RAF's Albemarle transport and the U.S. C-47 transport.[19]

Although 1,554 Horsas were produced by April of 1943, this was still not enough. The British were anticipating a production rate of 600 Horsas and 100 Hamilcars during 1943. This was increased to 900 Horsas for 1944 with twenty-five percent more possible with a higher priority.[20] The twenty-five percent extra was based on a U.S. calculation because during 1943, the U.S. was losing three to six gliders a day in training. The U.S. estimated twenty-five percent above requirements could cover losses in training.[21] Although only thirteen British Hamilcar gliders were used on the first day of Market, it was significant.

ILLUSTRATION THREE
GENERAL AIRCRAFT HAMILCAR



Reprinted, by permission, James E. Mrazek, Fighting GLiders of World War II, (New York: St. Martin's Press, 1977), 65.

The Hamilcar was the largest allied glider as well as the largest wooden aircraft built during World War II.[22] The Hamilcar was designed for the requirement to move heavy vehicles including light tanks during an airborne assault. It had a payload of forty troops or 17,500 pounds of cargo.[23] (See Illustration Three.)

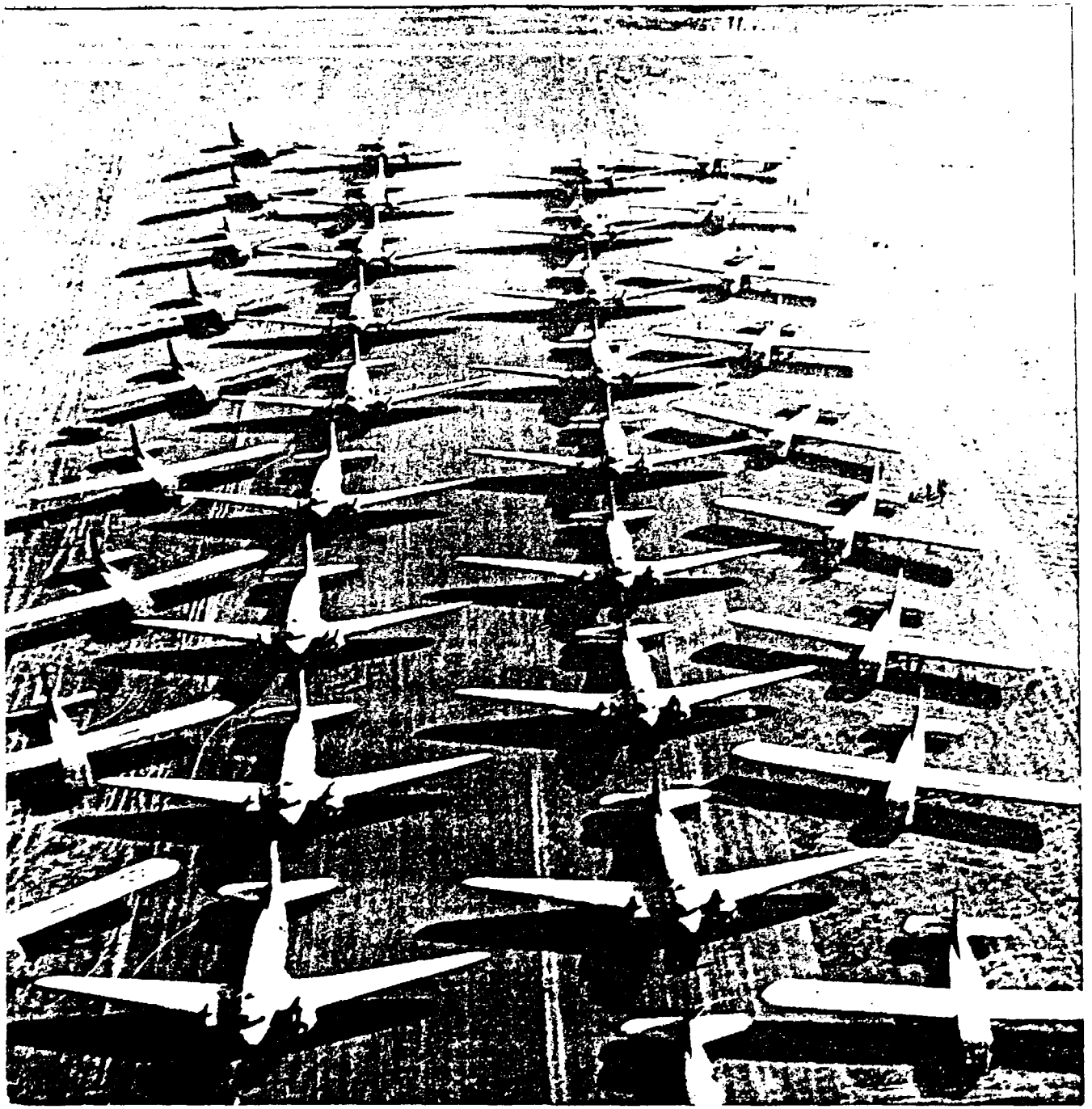
The first Hamilcar was flown on 27 March 1942. General Aircraft built twenty-two and subcontracted another 390 out to woodworking firms such as the Birmingham Railway Carriage Company and Waggon Company, Limited.[24] Towing was as the CG-4A. (See Illustration Four.)

Direct comparisons between the Horsa and the Waco vary in their description of which was the better glider. S.L.A. Marshall's Night Drop, chronicles the airborne assault into Normandy and describes the Horsa as "splintering into matchwood" upon landing compared to the CG-4As remaining "intact." (See Illustration Five.) The personnel parachute program of the U.S. and the British however, provides a greater comparison between two different airborne systems than the glider does and will be examined next.

The United States Parachute Program

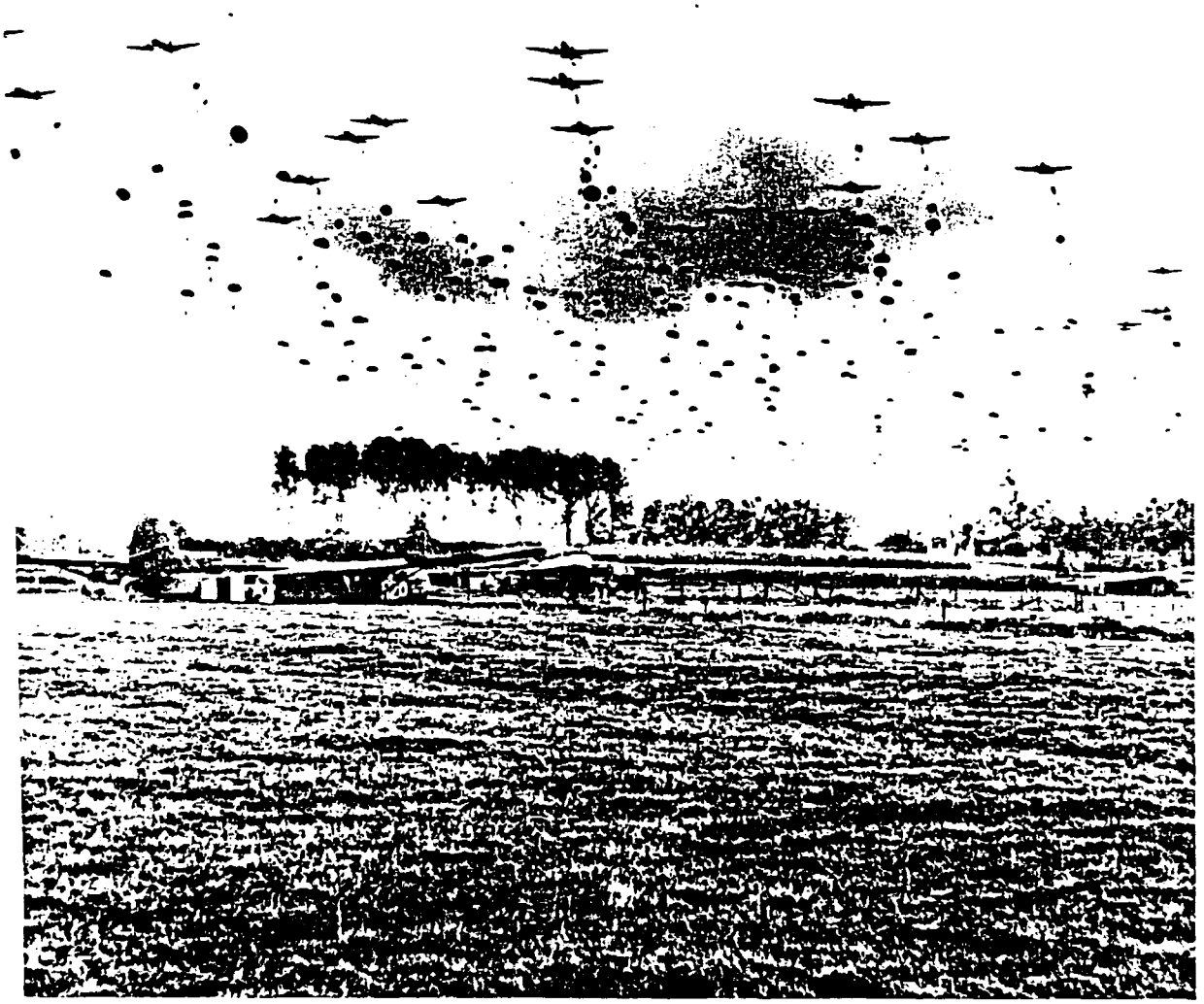
The Army Air Corps had managed the parachute program based on the small requirement for parachutes as a safety device for the rare moment when a pilot had to jump from a disabled aircraft. The larger requirement for thousands of soldiers to deliberately jump in training and in combat placed strains on an already committed system.[25] Three parachute regiments were organized and began training at Fort Benning, Georgia in 1942.

ILLUSTRATION FOUR
C-47 TUGS AND CG-4A GLIDERS READIED FOR USE



US ARMY Photo, 17 September 1944

ILLUSTRATION FIVE
PARACHUTISTS AND GLIDERS NEAR GRAVE, HOLLAND 23 SEPTEMBER 1944



US ARMY Photo, 23 September 1944

ILLUSTRATION SIX
US PARACHUTISTS WITH T-7 PARACHUTES AND RESERVES

US ARMY photo, 17 September 1944

ILLUSTRATION SEVEN
BRITISH PARACHUTISTS WITH X-TYPE PARACHUTE

US ARMY Photo, 17 September 1944

The parachute issue was based on two parachutes per man. The Army stated this as a requirement for 8,654 parachutes in 1942.[26] (See Illustration Six.)

The Irving Parachute Company had contracted with the Army to produce 200 parachutes per week starting in September of 1941, but fell behind schedule. The Switlick Parachute Company promised 3,750 T-5 parachutes by July 1941, but was also unable to meet schedule.[27] Finally, parachute production met the demands of the large numbers of soldiers going through jump school. Production schedules were expanded and the parachutes supplied to the units needing them. A modified quick-release harness, based on a German design, resulted in the adoption of the personnel parachute the Market jumpers would use, the T-7 parachute. The T-7 was adopted in December of 1943.[28]

The British Parachute Program

The British airborne forces used a reliable personnel parachute called the X-type parachute. It was a silk or rayon canopy, twenty-eight feet in diameter with a twenty-two inch central vent. The parachute had a relatively shock-free opening and was considered so reliable that no reserve parachute was used.[29]

So reliable was the X-type, that British airborne forces did not adopt the standard U.S. practice of jumping with a reserve parachute until 1956. In fact, when the British made the combat parachute assault into the Suez in 1956, most elected to discard the reserve parachute and carry more ammunition instead.[30] (See Illustration Seven.)

Training the Airborne Force

Training United States Glider Pilots

The idea of training glider pilots for the Army started in 1929 when civilian sport glider enthusiasts tried to integrate glider training for Army pilots. Unfortunately, the Army rejected the idea after conducting a survey among its pilots. This survey announced that introducing gliding in Army flying schools served "no good purpose."[31]

World War II and the German success with gliders brought about the need for a U.S. glider program so training began in 1941. The training evolved during the war with students initially getting forty hours of training in light planes before transitioning to gliders. Glider training was conducted at an elementary glider school first. Following the elementary course, students would attend advanced glider schools scattered across the country.

Initial organization of the program was poor. Students complained of poor living conditions, and the discipline was either too harsh or too lax. Many of the promised promotions never came, or were slower than promised. A lack of gliders kept many students grounded for long periods of time.[32]

Many of the glider pilots who flew in Market trained as part of the Army's 6,000 Glider Pilot program beginning on May 8, 1942. This program followed the 4,200-man program and was the largest group of glider pilots trained. A directive issued by the Chief of Air Staff required 6,000 trained glider pilots by December 31 1942. This directive reduced training time to a total of six weeks.[33]

Two types of students entered the program. A Class A student was one who had some type of previous flight training or experience. Examples of the type of training to qualify as a Class A student were holding an airman certificate, having 200 or more glider hours, or having had at least fifty hours of flight instruction.

Trainees in the 6,000 program received thirty hours in the first four weeks on cub-type powered aircraft. Then they received eight hours in two-place gliders followed by eight hours on fifteen-place gliders for a total of forty-six hours. The requirements for the program were for students to be between the age of eighteen and thirty-five and never have been failed in a course of flying instruction. Aviation officers of the Army who were also rated pilots could also apply.[34]

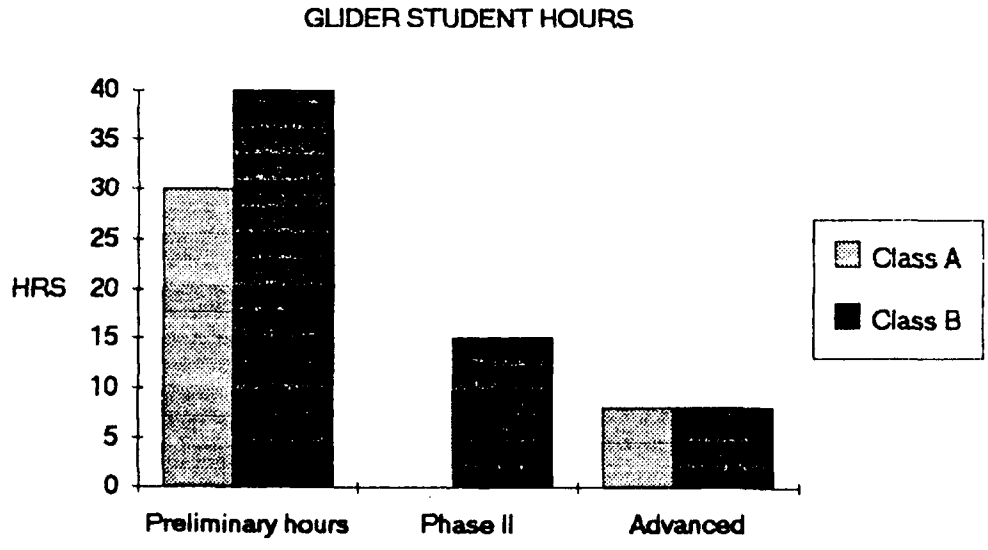


Figure 1--2. Glider Student Hours in Training
SOURCE: USAAF Historical Studies Number 1, The Glider Pilot Training Program 1941-1943. 53.

Unlike the training of paratroops, conducted primarily at Fort Benning, Georgia, eighteen different locations supported glider schools. Civilian contract pilots operated most of the schools. Perhaps the civilian nature of the training resulted in a lack of combat training for the glider pilots. This lack of a coordinated effort to give combat training to the glider pilots resulted in severe criticism of their function on the ground later in the war. As an example, close to 1,000 glider pilots assembled in the objective area in the Market operation with no further mission than to carry a load of ammunition to the nearest battalion command post.[35]

The poor focus on ground combat training for the glider pilots is understandable considering how little was known of the glider pilot's role in 1942. He would be part of an airborne unit, and upon completion of his transport mission, take part in some ground combat. The directive for the 6,000 program specified the ground combat training of the pilots, but provided no resources for the training to occur. Glider pilots expected the majority of the combat training to happen in exercises with airborne divisions.

Doctrine, if not practice, caught up with the role, mission, and function of the glider pilot in 1942 when more specific guidance was issued. This guidance said the glider pilot was to land safely, expedite the unloading of his glider, secure his glider, and participate in ground combat only in "exceptional circumstances."[36]

The contract schools did not have the qualified instructors or facilities to conduct this ground combat training, and the Army's attempt to institutionalize such training never reached the level of ground

combat training the British Glider Pilot Regiment achieved. A glimpse into the level of detail provided by the flight training will show that not much time was available for much ground combat training during the flight portions of glider school.

The first thirty hours of instruction was to simulate glider flying as close as possible and was conducted in light planes to save damage to the gliders. Given during the first twenty days of training, flying skills were devoted to powered off dead-stick landings from 2,000 feet. The landing gave the student a feel for powered-off flight.

Five hours of flight training taught the student to make a powered-off approach to a precise point on the ground without using brakes. Students landed to strange fields from 5,000 feet in daylight and darkness. Dead-stick landings taught the student to judge the distance and correctly use technique to land safely. Students landed to a chalk mark on the landing field. This training gave the student confidence and translated to heavier gliders later.

A sixty-hour ground school was also included in the training. The course called for twenty days of instruction and used two manuals as basic texts.[37] These small manuals served as basic reference for the student. Both of these, TM 1-800, Basic Glider Training,[38] and TM 1-815, Advanced Glider Training,[39] guided the student's instruction.

Once the elementary phase of training was completed, the glider student attended an advanced course. The advanced course, still part of the six-week total, taught students the finer techniques of handling a glider including more detailed hook-up and towing procedures. Students flew the CG-4A in this phase, but in many cases, a shortage of CG-4A

delayed the advanced phase for many students. Revised training estimates lengthened the time to train a glider pilot to as long as ten weeks in some schools.[40]

The long wait between elementary and advanced training for some students hurt morale. Rank structure for glider pilots hurt morale also, and deserves mention here. Graduates of the glider pilot course with no previous experience received appointments as flight officers in the Army Air Corps. Flight officers ranked below a Second lieutenant, the Army's most junior commissioned rank, but above enlisted ranks. Those students already holding commissioned rank were allowed to keep it. Future promotion of glider pilots was tied to unit Table of Organization and Equipment (TO&E) slots in troop carrier units.[41] Many glider pilots also received specialized training as glider mechanics.

Following an Army report in early 1943 stating that at any one time as many as seventy-five percent of the CG-4As owned by the Army were grounded for maintenance, the Army established a technical inspection system for gliders.[42] Failure of the landing gear components was blamed on faulty pilot technique and poor skill transfer from the light powered aircraft used to train glider pilots. The lack of a long development process for the CG-4A was also blamed on many of the structure failures. The Army report also alluded to a deliberate decision by the Army not to implement further changes to the CG-4A because of the long grounding time such changes would require. The changes would have happened at a time when all CG-4As were urgently needed for training. The Army report concluded that the cargo glider was built with the specific mission of accomplishing one transport flight, not be

used as a 400 hour training device.[43] Another result of the report was the mechanic training for glider pilots.

The Air Technical Training Command arranged to train 100 glider pilot students every ten days. Every ten days, glider pilots who could not immediately begin advanced training would report for the sixty-five day Glider Mechanic Course. This course proved important to the glider pilot, especially the ten days of instruction devoted to crating, uncrating, and assembly of the glider. Later, the course for glider pilots was modified and reduced to thirty days with emphasis on supervising glider maintenance and inspection of an assembled glider.[44]

A limited experiment late in 1943 highlights the Troop Carrier Command's estimate on the value and cost of training glider pilots. The Troop Carrier Command conducted an experiment with a pool of excess power pilots, rated aviators qualified in the AAF's powered pilot course. These pilots transition in the CG-4A glider with a minimum of instruction. This instruction was basically an orientation flight with evaluation at the end. The powered pilots scored higher than the average glider pilot graduate. Furthermore, the Troop Carrier Command stated that a glider-only pilot was of limited value when assigned duties other than directly piloting a glider.[45] The report of the same experiment found the expense of training powered pilots was less in time, money, and material than the training of glider pilots.

About the same time as the Troop Carrier Command's experiment, the British RAF and the U.S. Air Transport Command experimented with the concept of towing gliders across the Atlantic. This was to have a cost effect of reducing the number of powered aircraft to move

equipment from the U.S. to England. The experiment set a record for a glider tow, but was a failure as a demonstration of the cost effectiveness of the glider.

The Air Transport Command's towing tests with the CG-4A concluded that the efficiency of a C-47 towing a glider was poor compared to the airplane alone. The test used a C-47 and CG-4A combination loaded to 28,000 pounds against a C-47 loaded to 31,000 pounds alone. This was the first transoceanic glider flight, a distance of 3,500 miles, and was never duplicated.[46]

The British Glider Pilot Program

In the British glider pilot program, only one in twenty-five would win the coveted glider pilot wings. The Royal Air Force(RAF) believed the glider pilot should be capable of flying fighters or bombers so it devoted more time to the training of its glider pilots. This concept was not adhered to throughout the war, and most of the glider pilots used in Market were rated in gliders only.

Another training concept the British remained committed to was the idea that the British glider pilot was an infantryman who could also fly gliders. The glider pilot, in the British view, should fight on the ground when needed. The British realistically expected a large number of glider pilots on the ground during a large airborne assault and planned to use them in some ground combat role. The British casualty figures among its glider pilots also reflected this belief.

The RAF obtained company sergeants major from the Brigade of Guards of the British Army. These Noncommissioned Officers (NCOs)

organized a training regiment for the glider pilots. The psychological discipline of the glider pilot training regiment produced a pilot who could fly and fight. After a basic pilot course in a two-place trainer called a Tiger Moth, the British glider pilot attended a day-only, one month course in the British Hotspur glider. After this course, the student was awarded "2nd Pilot" wings. These were essentially copilot wings; to earn 1st Pilot, more training followed.[47] As an example of the product of the British glider pilot training, the operation code-named, "Pegasus Bridge" is instructive.

Pegasus Bridge was designed to seize a pair of bridges crossing the Orne River and Caen Canal about six miles inland from the Normandy invasion beaches.

These bridges provided the Germans with the capability to rapidly reinforce the coast. British Major John Howard, commander of the small raiding party to seize the bridges, was given a choice of glider or parachute insertion of his force. He chose gliders and was given six Horsa gliders and their crews to train for the operation about eight weeks prior to the invasion.

Howard believed the stealth and accuracy required of his mission was suited to the gliders. The six gliders and their crews trained using mock-ups and flew during darkness. The glider pilots were all given a ground combat mission following landing. The landing was successful and the objective seized with no loss to the gliders or crews.[48] This successful glider operation was recreated in a popular board game called, "Pegasus Bridge." This game uses dice to determine successful landings by the gliders.[49]

All of the British glider pilots were members of the Glider Pilot Regiment. The regiment was a large unit. The glider pilots were assigned to subordinate squadrons and were usually given a ground combat mission. They were employed under their Glider Pilot Regiment chain-of-command and were usually given some form of on-order ground combat mission. In Market, as an example, the British glider pilots were used for defense of key points and distinguished themselves in this role.[50]

The Training of Paratroopers

By the time of Market, airborne units had suffered heavy casualties in previous operations. Airborne commanders wanted to fill their depleted ranks with parachute-qualified soldiers.

A request to the War Department for in-theater training of parachutists was disapproved. In a message to the airborne divisions, commanders in the field were told all replacement airborne training would be conducted at the Airborne Training Center at Fort Benning, not in North Africa or Europe.[51] This guidance was later changed allowing theaters to train urgently needed parachute replacements, but only in specific units. Theaters were authorized to train infantry replacements as parachutists up to a strength of fifteen percent above TO&E. This was authorized only in the Thirteenth Airborne Division, the 541st Parachute Infantry Regiment, and the 542nd Parachute Infantry Battalion. Theaters trained 3,000 parachutists between July and September of 1944.[52]

The Airborne Training Center believed it could provide enough qualified parachute replacements at this phase of the war because all of

its resources used to train the airborne divisions could now be devoted to individual replacements. The eight-week course at Fort Benning was designed to train soldiers to jump, land without injury, and carry out a ground tactical mission. Soldiers were also taught to pack and inspect their parachutes, and the principles of a mass tactical jump.[53]

The basic course was divided into six phases. For packing instruction, fifty-two hours was given. For jump training, another fifty-two hours, and for tower training, thirty-six hours. Equipment drill took twelve hours followed by eight hours of lecture. The final five qualifying jumps were assigned forty-eight hours. The total training was not to exceed one month of twenty-six days, each day lasting eight hours.[54]

The British parachute course was equally demanding. The major difference affecting this study was that the British made several of the qualifying jumps from a tethered balloon. This had cost effectiveness strengths not associated with the U.S. program.[55]

The commander of the Airborne Center at Fort Benning made a decision in late 1943 that stopped training individual replacements for glider units. These were not the glider pilots, but the glider troops in the glider regiments of the airborne divisions. Glider replacements could be trained in a short period of time after arrival in an airborne division. A division, it was believed, could be trained to use gliders in only five weeks.[56]

The Assembly and Packing Elements

In major airborne operations involving gliders and parachutes, a considerable effort in time and manpower was spent in two labor-intensive functions. For the gliders, they were uncrated, assembled, inspected, and time permitting, test flown. For the parachutes, they were unpacked, inspected, repacked, and reinspected. Both of these functions used manpower to get these items of airborne equipment ready for use.

In Market, the First Allied Airborne Army used the Twenty-sixth Mobile Repair and Reclamation Squadron to assemble gliders. Based at Cookham Common, the Twenty-sixth assembled 1,Ø45 CG-4As by 1 July 1944 in anticipation of Market. This number was only enough for one glider echelon of one division. From 8 August, an assembly line at Cookham prepared forty gliders a day. The line used twenty-six officers and 9ØØ men working in three shifts with automobile assembly line techniques. On several days, the line assembled sixty and once even 1ØØ gliders. By the end of August, 1,629 gliders were ready for the Ninth Troop Carrier Command's use. By 15 September, 2,16Ø gliders were assembled. The Market plan called for ninety percent of these gliders.[57]

The glider pilot problem for Market could not be solved as easily. By the end of August, 1,9ØØ glider pilots were on hand. At the first of September, 2ØØ more arrived from the U.S. The shortage was still severe enough however, to prompt General Lewis H. Brereton, commander of the First Allied Airborne Army, to decide to select copilots from anyone willing to ride up front in a glider.[58]

Recovery of Gliders and Parachutes

The costs of parachutes and especially gliders demanded their quick recovery so they could be used again. Unfortunately, this did not happen often and many gliders and parachutes were abandoned in combat. To prevent this, glider units developed recovery techniques to pick up gliders after an assault. One technique used a tow rope attached to two poles about fifteen feet off the ground. The other end of the tow rope would be attached to the glider. A C-47 would swoop in low and snatch the glider and its cargo off the ground. Typical uses for this technique were to recover glider pilots and wounded. Other utility uses for gliders were as mobile field hospitals, and field kitchens although this was seldom done.

Recovering parachutes was as important as recovering gliders. Obtaining serviceable parachutes was such a problem that Major General James M. Gavin made it a court-martial offense for a soldier to be caught with parachute cloth around his neck. Many soldiers, some not even in airborne units destroyed parachutes to make scarves, ground sheets, or for local barter.[59] General Gavin, wartime commander of the 82nd Airborne Division, on the recovery of parachutes said,

> The retrieving of parachutes is essential. I do not see how you can say we are not going to recover parachutes. Parachutes are very costly and it is difficult in war to obtain them, particularly, some of the components.[60]

The nature of airborne operations sometimes prevented recovery. The same was true of gliders. The point is that gliders and parachutes

were not expendable. Although generally regarded as expendable in the sense that a glider made an unpowered and certain descent on an LZ, attempts were made on every operation to recover gliders. Recovery rates varied from one out of six gliders recovered following Operation Varsity where a deliberate recovery plan was executed to fifteen out of seventeen recovered during a night operation in Burma.[61]

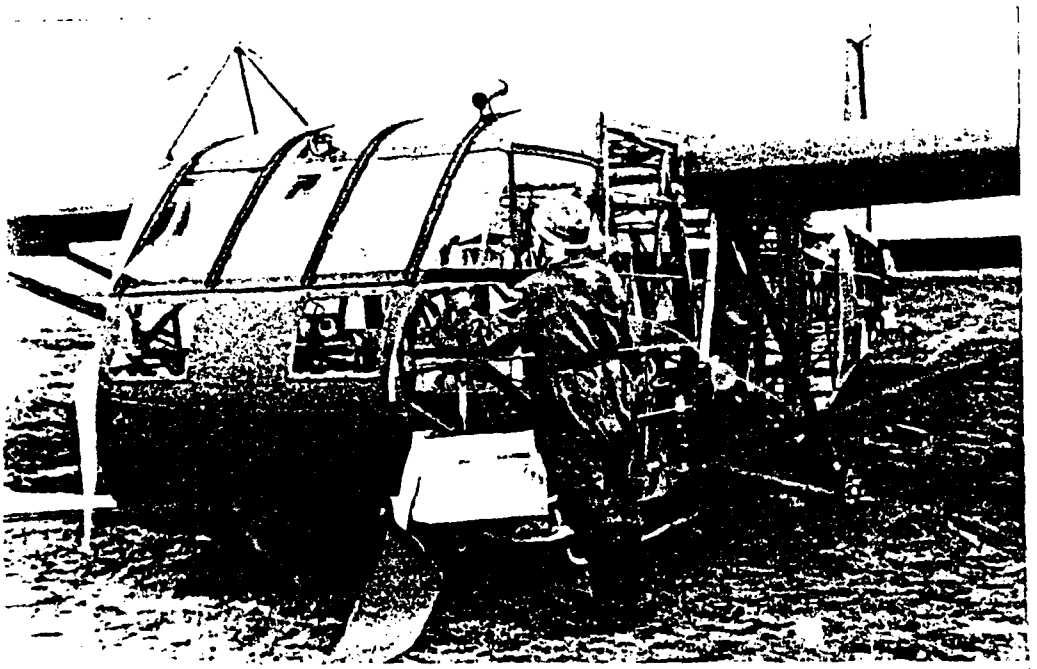
Only 350 gliders out of 1,926 CG-4As were recovered following Market. This is a recovery rate of only thirteen percent. Most of these were not recovered until December of 1944.[62] In the Army's 82nd Airborne Division's Army Ground Forces Report 440, Combat Lessons of the 82nd Airborne Division, 9 December 1944, damage to gliders and parachutes was called, "willful destruction," and "misappropriation."[63] (See Illustration Eight.)

Postwar Glider Use

The loss of gliders in battle was but one reason for their demise. Following the war, gliders continued to serve until the early 1950s. Although statistically insignificant, two primary sources, interviewed during research provide valuable insight into the glider problem.

Captain Herman L. Alley commanded A Battery, 456th Parachute Field Artillery in the 82nd Airborne Division. Although he believes gliders would not be cost effective today, he assaulted into Market with his battery in gliders because of a shortage of parachutes. During the earlier Normandy invasion, only one-third of his battery was able to parachute into Normandy in June of 1944 because the remainder of his battery was not parachute qualified. These soldiers went in by glider.

ILLUSTRATION EIGHT
ABANDONED CG-4A IN HOLLAND



Photograph furnished to Silent Wings by
J. A. A. Labro, of Molenhoek, Holland

An unidentifd Cerman trooper looks over an abandoned American CG4A glider after it landed in enemy-held territory during the Market Garden operation. This glider, one of the 1,899 CG4As committed to this action, appears to have suffered very little, if any, damage in its landing. It is believed that the serial number of this aircraft was 43-19851. Note the missing landing gear wheels — Local residents found these wheels to be highly valuable and used them for farm carts. Probably many such carts are still in use today!

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The advantage of going in gliders, according to Alley, was that his battery was in position and firing within one hour of landing during Market.

Alley's glider was so damaged on landing that his driver had to use an axe from his jeep to chop their way out of the glider. Fortunately, said Alley, no one was injured in the landing. "Most" of the gliders Alley saw were not worth recovering, and he said he never had time to recover any parachutes. Alley believes the glider's speed and accuracy contributed to his unit's success.[64]

Another veteran was Captain Frank D. Boyd. Boyd served as a liaison officer in the 376th Parachute Field Artillery Battalion. This unit was the first to parachute an artillery battalion in combat. Boyd wrote that his unit could only assemble ten of its twelve howitzers on the drop zone. The 75mm pack howitzers were dropped using six bundles attached to shackles under the C-47. A seventh bundle contained the howitzer's wheels and was dropped from the door of the C-47 as it would not fit in a shackle.

Boyd said he never packed a parachute after jump school. This function, according to Boyd, was done by parachute riggers who also jumped in to recover parachutes from the drop zone. Because of the time and equipment needed to drop howitzers, Boyd believes the glider was more effective during the Market operation.[65] Another source was able to confirm the huge effort required to pack parachutes.

Captain Arnold Moer served as a rigger in the 82nd Airborne Division's parachute maintenance company. The company was formed from riggers in the parachute regiments. The mission of this unit was to pack

parachutes at the division level by consolidating all riggers in one organization. This unit had about 100 soldiers and spent much time inspecting and packing parachutes.[66]

The Army's review of glider performance however, was mixed even though it stated that glider units assembled faster than parachute units.[67] The commander of Market gave a mixed report of the glider's performance. In a letter outlining difficulties of the Market operation, General Brereton, commander of the First Allied Airborne Army, said, "the glider, while valuable, has limited application."[68] Even with General Brereton's remarks, the Army continued development of the glider.

As late as 1949, the Army was still developing new gliders. In a test of the YG-18A glider, the Army attempted to correct the deficiencies in the CG-4A. These limitations were mainly payload and construction problems. The newer gliders offered increased payload and were metal-skinned for strength and fire protection.[69] This new glider appeared too late. Many of the problems with the U.S. glider program stayed in the minds of Army planners. The Army failed to appreciate, early in the war, the full potential of the glider as was reported to the Secretary of War during World War II.

> There exists an insufficient appreciation of the effectiveness of the glider as an instrument of war and a general apathy on the part of all echelons with respect to glider training. This attitude seriously impaired the development of proper technique in employing gliders.[70]

After the war, the government began selling crated CG-4A gliders for $75 each. Five large shipping crates carried a single glider, and the glider itself used more than 10,000 board feet of grade A lumber. Gliders were bought for the lumber and shortly after the war few CG-4As remained. In January of 1991, the retail price of 10,000 board feet of grade A lumber cost $4,975.00 in Kansas.[71] As of 1990 however, only five complete CG-4As remained. Considering that the U.S. built 14,612 gliders and the British built 5,935,[72] the small number that survived is testimony to perceptions of the glider's continued utility at the war's end.

The commander of the 82nd Airborne Division, Major General John M. Gavin wrote in 1947 that future airborne operations must get away from the escort planes and "miles of rope"[73] used in an airborne operation. These comments indicate that Gavin was searching for a better glider or a more capable aircraft to carry his paratroops. A historian disagreed with Gavin and viewed the glider's weakness as a fault in U.S. employment technique.

The U.S. typically led with paratroops and followed with gliders. This, according to the historian, only alerted the defenders to the glider's arrival. The British experience tends to reinforce this idea because the British frequently led with gliders and consequently had fewer glider casualties in the assault. The surprise effect of intact units landing together was afforded only by the glider.[74]

In 1951, the glider still had its champions in the Army. An officer writing in Infantry Journal argued that the glider remained the best means of delivering troops and equipment. The author said the rapid

assembly time and payload remained advantages of the glider.[75] Some data from the war confirms the article's point of view. For example, in an after action report from the Market operation, supply drops by parachute were called wasteful and unreliable.[76] Gliders, for both assault and resupply, were considered successful if landing zones could be identified and anti-aircraft fire was minimal.[77]

Airborne historian Ernest K. Fisher favored the parachute over the glider because of the long columns of aircraft the glider-tug combinations required. The long tow ropes and aircraft were not as efficient as the troop carrying aircraft alone.[78]

The glider, as used in World War II, faded from use around 1951. The successful paradrop of the 187th Airborne Regimental Combat Team in combat during the Korean War in 1951 proved the feasibility of parachuting heavy equipment previously carried by the glider. Development of the newer gliders ceased and efforts to perfect parachute delivery increased. Edward M. Flanagan, a retired U.S. Army lieutenant general, and writer of the "Before the Battle" column featured in Army served as a parachutist and gliderman in World War II. As a young major in 1951, he wrote an epitaph for the glider in Infantry School Quarterly. In the epitaph, Flanagan called the World War II glider an "oversized kite-- vibrating bag of plywood and canvas; nose diving, hedge cutting, man and equipment killer."[79] Flanagan was uniquely qualified to make such statements. He commanded an airborne field artillery unit in combat and served most of his career in airborne units. Although Flanagan favored the parachute over the glider, the glider

concept would surface thirty years after Flanagan heralded the glider's death.

Contemporary Glider Concepts

The military potential of gliders surfaced again in the late 1970s. Two studies, one by the United States Air Force, and one by the United States Navy, considered military applications for gliders.

The Air Force study sought new strategic airlift concepts, one being a powerless glider and powered tug combination. The study cited savings in procurement and reduced operating costs as advantages of the glider. The proposed glider would have a payload of between 200,000 and 800,000 pounds-- well beyond that of a World War II glider.

Unfortunately, no existing aircraft were found suitable for the tug role. A higher cost tug and glider would have to be developed at a higher cost than a single system. The Air Force glider never left the concept stage.[80] The Navy's glider study targeted a lower flight envelope, one of special operations capability.

The Navy study examined Powered Hang Gliders (PHGs) for Marine and Navy special warfare units. The mission profile involved inserting small teams and performing limited reconnaissance missions. The glider required a range of 200 nautical miles. The Navy tested and selected the "Quicksilver M" PHG. Of significance to this study was the low radar cross-section, low cost, and survivability of the PHG. While the PHG only carried two people, it demonstrated a modern attempt at a cost effective glider. The PHG demonstrated a search for a capability not found in the current inventory.[81] While the PHG concept did not gain acceptance in the U.S. Navy, it did not go unnoticed. Palestinian groups used hang

gliders in combat against Israeli positions during a terrorist attack in the early 1980s.[82] Obviously, the terrorists saw the PHG as a cost effective, viable stealth aircraft. This study however, uses a heavier model, a model based on a combat scenario. This study holds significance in three significant areas.

Significance of the Study

Historical significance

As a historical review of the first day of the Market operation, this study focuses on the initial airborne assault. The first day, from an airborne assault perspective was successful. This study ties costs into a historical framework. As such, this study provides a comprehensive historical review of the first day's assault. This study looks at the tactics, techniques, and procedures used during large airborne operations and will contribute to the historical study of World War II.

Operational significance

This study is an operational one in that its view is from a cost effective approach and identifies the major costs associated with the world's largest airborne operation. In examining the major costs, areas for improvement are selected. These areas are in training and equipping an airborne force. Accordingly, this study is of importance to anyone concerned about the costs of military operations.

Future significance

This study alone cannot bring back the glider. It does however, identify the major costs of using gliders. This holds importance in planning for three areas of future air delivery. The three areas are

strategic airlift, tactical airlift, and special operations airlift. In each of these areas, this study is applicable in identifying weaknesses in Market. If the glider concept returns, in any of the three areas, this study provides valuable information regarding the shortfalls, the traps, and the successes based on actual glider use.

In the next chapter, the review of literature will show how several authors attempted reexamination of the glider cost effectiveness.

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CHAPTER TWO

LITERATURE REVIEW

This study explores new ground. The focus of this thesis, a cost effectiveness comparison between glider and parachute assault based on a single day of actual combat, has never been addressed. Therefore, the literature review as to the cost effectiveness research question is deliberately narrow.

In the forty-five years since the last glider combat assault, only one study addressed a direct comparison between parachute and glider costs. Another study immediately after the war examined the costs of parachuting equipment. Both of these studies are reviewed here in detail.

The Buttolph Staff Study

In May of 1949, a U.S. Army student at the Command and General Staff College at Fort Leavenworth, Kansas wrote a detailed staff study titled, "The Case For Parachute Landing of Material and Personnel As Opposed to Glider and Airlanding."[1] Loren D. Buttolph was a lieutenant colonel at the time and author of the study. His conclusions came at a time when the assault transport was a required operational capability in the minds of many airborne commanders. Buttolph's study made four conclusions.

Buttolph's Conclusions

Parachute drops of personnel and equipment will continue as a part of warfare. Night assaults in areas unsuited for glider landings would mean the parachute and its attendant training and costs would remain a capability of the U.S. Army.[2]

Glider troops can be assaulted in combat without the specialized training required of parachute troops. The glider unit will land more intact than a parachute unit. The costs however, of gliders with their historically low wartime recovery rates require that gliders remain a special piece of airborne equipment with limited use.[3]

Assault aircraft would provide the accuracy and payload of gliders without the attendant costs of training parachutists. Assault aircraft would delete the requirement for all specialized equipment associated with both gliders and parachutes.[4]

Parachute training and capability should be held to a minimum to save costs. Gliders should be kept, but as specialized piece of airborne equipment used only under strict conditions considering their high cost. Assault transport aircraft would offer savings in airborne operations.[5]

Buttolph's recommendation

Assault aircraft be developed as the most cost effective means of delivering troops and equipment. Gliders and parachute assault capability should be practiced, but kept to a minimum.[6]

Buttolph's elements of cost

The 1949 study compared the training time to qualify a division in both parachute and glider assault techniques. The 1949 study used time estimates from the parachute school at Fort Benning, Georgia. At that

time, a six week qualification course was offered. In comparison, a one week course, based on Buttolph's survey of officers, was all that was required to qualify a division in glider or air land techniques.[7]

Equipment costs were considerably lower for the glider troops than for the parachute troops in training. The costs in the 1949 study did not include the capital equipment costs such as the gliders themselves, but looked at things such as parachute drying facilities, jump training towers, and wear and tear of parachutes.[8]

The 1949 study did examine salvage costs. Buttolph used a recovery rate of fifty to ninety percent for the parachutes and associated items. He used a fifty percent recovery rate for the gliders, and did not measure the assembly and transport costs. Buttolph did however, accurately identify the transport and assembly effort of gliders as major costs even if he did not assign a dollar figure to them.

Table 2-1 Basic Airborne Course Costs

Number of school troops	500
Number trained weekly	800
Cost of rigger facilities	$1,000,000
Cost of jump towers	$250,000
Cost of jump aircraft	unknown

Source: Loren D. Buttolph, "The Case For Parachute Landing of Material and Personnel as Opposed to Glider and Air Landing,: United States Army Command and General Staff College, 31 May 1949, Annex C.

Table 2-2. Cost of Glider and Air Land Training

Number of school troops	80
Number of troops trained	1 division
Cost of training aids	unknown
Cost of aircraft	unknown

Source: Loren D. Buttolph, "The Case for Parachute Landing of Material and Personnel as Opposed to Glider and Air Landing," United States Army Command and General Staff College, 31 May 1949, Annex C.

Table 2-3. Cost of Equipment in Division Airborne Operations

PARACHUTE ECHELON		GLIDER ECHELON	
Parachutes	$1,250,000	CG-18A Gliders	$1,780,000
Special Equipment	$750,000	Special Equipment	N/A
TOTAL	$2,000,000	TOTAL	$1,780,000

Source: Loren D. Buttolph, "The Case for Parachuting Landing of Material and Personnel as Opposed to Glider and Air Landing," United States Army Command and General Staff College, May 1949, Annex C.

The second cost study focused mainly on the costs of parachuting equipment and supplies. This study compared the costs of parachuting supplies with landing supplies. The landing method could have been either glider or cargo aircraft. This study did not account for gliders damaged in landing.

The figures from the second study came from data gathered between 1 April 1943 and 31 December 1944. Market data was used in the figures. This second study came at a time when the Army was trying to

develop its parachute rigging and maintenance organizations. At the time, the newly formed United States Air Force shared some air delivery functions with the Army.

The Army wanted more responsibility and control in developing airborne techniques. The focus of the second study was to make a case for fiscal resources in Army hands for parachute equipment. These resources would enable the Army, the study indicated, to better support its requirements. The figures in the second study are less valuable to this research except as a tool to demonstrate the considerable costs in parachute type material associated with parachute delivery means.[9]

Table 2-4.-- U.S. Equipment Needed to Parachute 1 Ton

14	parachutes 24'	$72.35 each	$ 1,Ø12.9Ø
11	A-4 containers	$25.41 each	$ 279.51
2	A-5 containers	$44.75 each	$ 89.5Ø
3	A-6 containers	$35.ØØ each	$ 1Ø5.ØØ
3	A-7 straps	$ 3.ØØ each	$ 9.ØØ
14	parapack assy.	$1Ø.ØØ each	$ 14Ø.ØØ
224	rubber bands	.Ø1 each	$ 2.25
4Ø	yards brk cord	.Ø6 each	.25

Source: Department of the Army, Quartermaster Aspects of Airborne Operations, (Washington: Office of the Quartermaster General: 195Ø), 6Ø.

Table 2-5. Cost per Ton by Delivery Means

Glider Landed per ton	$49.61
Parachuted per ton	$1,909.65
Free-dropped per ton	$94.07

Source: Department of the Army, Quartermaster Aspects of Airborne Operations, (Washington: Office of the Quartermaster General, 1950), 60.

Significance of Previous Studies

These two important cost studies point to savings in using gliders. Both studies illuminate several hidden costs associated with conducting parachute delivery of troops or equipment. These costs are in training because in the instance of troops, all must be qualified and current parachutists. In the instance of parachuting equipment, huge costs are associated with the parachutes and other hardware needed to successfully perform the paradrop. These costs, as shown by these two studies, are not a component of glider operations.

Glider operations however, have their hidden costs also. The huge effort required to assemble gliders before every major airborne operation is an example of the glider's hidden costs. In the next chapter this study will examine five major costs of both parachute and glider assault applicable to the research question. Before proceeding with this study however, a contemporary reassessment, not relating to cost, is instructive in understanding the role, mission, and function of the glider.

Wolfe's Glider Assessment

Martin Wolfe served in the 81st Troop Squadron in World War II. He was a radio operator on a C-47, but recorded the day-to-day life inside a troop carrier squadron. The unit flew in Market. Wolfe wrote a comprehensive narrative of its operations and he kept an accurate roster of members of the squadron and was able to interview many for his narrative. The narrative was published as Green Light! Men of the 81st Troop Carrier Squadron Tell Their Story.[10]

Wolfe devoted an entire chapter to reassessing glider potential and performance. He described four problems with gliders. These problem areas were: (1) glider airworthiness; (2) glider crashworthiness; (3) ground role of the glider pilot; and (4) perceived delays of glider pilots in returning from landing zones.[11]

The glider airworthiness issue, according to Wolfe, was a myth. The Waco and the Horsa were durable, capable aircraft. Both required an understanding of their capabilities and limitations however, for successful employment. The crashworthiness issue was another matter.

Wolfe's review reported that an atmosphere of "every man for himself carried the day upon the glider's release from its tow ship."[12] This attitude resulted in glider collisions over LZs. Considering the number of broken gliders the average soldier saw on an LZ, this criticism was justified. The gliders however, crashed as well as any aircraft making unaided, night landings on uneven terrain. Wolfe's criticism of the glider pilots' inability to function as infantry has already be discussed. In this examination of the literature, many

instances of personal bravery by glider pilots are a matter of military record. The problem, as viewed today, was a matter of command and control once the glider mission was complete. The final criticism in Wolfe's book is the glider pilot's perceived delay in returning to base after a mission. Again, the command and control of glider pilots was never adequately addressed so the delays were understandable even though damning to the glider effort.

Wolfe made only one cost comparison applicable to this study. He wrote that his unit received an abundant supply of everything including gliders. The $15,000 CG-4As his outfit abandoned would cost about $75,000 in 1990s dollars.[13] Although considerable today, this figure is low compared to the cost of powered aircraft.

The cost of some of the gliders Wolfe wrote about are examined in the next chapter. As this review has shown, no previous study included the five elements of cost this study applies to a single combat operation.

ENDNOTES

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CHAPTER THREE

THE METHODOLOGY OF COSTS

Introduction to Methodology

In selecting a cost-effectiveness approach to the study of gliders in Market, it was necessary to determine which elements of cost were applicable if this study was to assist future planners of airborne operations. Cost effectiveness studies involve more than just juxtaposing cost and effectiveness data and drawing conclusions. Meaningful comparisons are difficult to make whenever both the cost and levels of effectiveness of competing systems differ. In this study, an eight step process was used.

The first three steps involved reviewing the literature (see Chapters One and Two), determining the order of battle for friendly forces on the first day, and organizing those forces as they were employed on the first day (see Chapter Four). These steps produced a glider and parachute comparison for study. Step four determined which elements of cost contributed to the cost of the Market operation. Five elements were selected for inclusion in this study (see Chapter Three). Step five designed a measurement tool for the five elements (see Chapters One and Three).

Steps six and seven applied the Standard Unit Equivalents to the glider and parachute echelons from step three and compared them to each other (see Chapter Four). The eighth step answered the research question and presented conclusions and recommendations (see Chapter Five).

The cost studies in this thesis demonstrate a concept of determining the cost effectiveness of gliders compared with parachutes as a system of airborne assault. The model for this study is a historical, operational one; the first day of Market, 17 September 1944.

This study considered what were deemed the most significant factors for a valid comparison between the parachute and the glider. As mentioned in the limitations portion of Chapter One, some factors not considered were the costs of replacing combat losses of glider pilots suffered in Market, or the costs of deploying a glider-equipped airborne division overseas. Both of these areas surfaced from the examination of Market, but were eliminated from further study here. These two critical areas, in the author's estimation, were ancillary to cost-effectiveness, and were peripheral to answering this study's research question.

Typical historical studies fail to provide accurate data to solve the problem of costing of weapons systems or other pieces of hardware. Therefore, this study was atypical because it relates the selected elements of cost as they were then with a forward view to future glider use. In other words, the cost estimates have value for any evaluation of airborne assault systems. The glider was selected in this case because of the costs involved in fielding it were so great, and was so brief as an airborne delivery system during World War II.

Procedures

This study examined primary sources such as original operation orders and initial after-action reports for the First Allied Airborne Army, the First British Airborne Division, the 101st U.S. Airborne Division, and the 82nd U.S. Airborne Division. Next combat narratives and historical summaries were consulted. The purpose of this initial procedure was to establish a complete order of battle for each glider and aircraft load by unit for the allies assaulting into Holland during Market on the first day. The objective was to establish a level of detail down to each glider and aircraft load by unit. This level of detailed was established.

Next, the glider and parachute echelons for each division were organized as they actually were employed for the first day of Market. Each of the three airborne divisions employed in Market had a different mission, and accordingly organized its glider and parachute echelons with regard to the division's commander's concept of using his airborne division and available aircraft. Since the first day's available lift was the only day that went according to plan, this study uses the actual organization of the glider and parachute echelons in its comparison. The next task was to established a common element of measure between the glider and parachute echelons. Because a glider could obviously carry more than a parachute, some standard basis for comparison was required. The standard selected by the author was the Standard Unit Equivalent (SUE).

The SUE was developed because comparing tonnage delivered, as the Army initially did in its study of glider effectiveness, clearly favors the glider without pointing to its limitations. Other elements, such as number of troops delivered, fall short of an objective comparison because a C-47 with a troop load of eighteen will carry more troops always than a thirteen-troop CG-4A. These attributes of gliders and parachutes do not provide a valid cost comparison. When applied to this study in particular, traditional comparisons do not fit because so many more jump aircraft took off for Holland than did gliders. None of the three divisions equally split their forces between the glider and parachute elements of divisions. To compensate for this disparity and provide an objective measure, the SUE was developed.

The SUE is based on the value of the twelve-man airborne rifle squad. This is used as a base of combat effectiveness. In this study, all parachute infantry regiments and glider infantry regiments and their British equivalents were divided by twelve to determine the number of SUEs. Combat Support and Combat Service Support organizations were assigned a value of a five-man element to provide one SUE. Since the glider echelons did not deliver a large number of troops, the SUEs for the glider echelons was considerably less than for the parachute units. Consequently, this study examined the other critical equipment the gliders delivered to battle to determine SUEs.

For example, gliders delivered the 75mm pack howitzer. This weapon played a significant part in the battle. It provided fire support in the early phases of the assault, offset the lack of available firepower in the airborne division, and countered German ground assaults. For

this study, it was determined that a 75mm Pack Howitzer carried a SUE of 3.Ø in relation to the twelve-man infantry squad. In other words, the 75mm Pack Howitzer was assigned a value of three rifle squads. Other weapons and key pieces of equipment delivered by glider were also assigned a value. One of the sources used in assigning values were the comments of General James M. Gavin, Market commander of the 82nd Airborne Division. Gavin said the greatest contribution of the glider was to deliver to the battlefield antitank defense means, jeeps, and other equipment that Gavin rated in order of importance.[1]

The SUE is a relative operational value based on the following criteria:

1. Mobility: how mobile was the piece of equipment both in the context of loading it for glider or airborne assault, and how fast could it be placed into operation? Also included in this category was the degree of mobility provided to the ground forces.

2. Lethality: how lethal was the weapon in its ground employment? Particularly high in determining the SUE was the weapon's tank-killing equivalent as this rated high of General Gavin's list of requirements for glider-delivered weapons?

3. Crew: what was the crew requirement for the weapon or piece of equipment?

4. Weapon/Vehicle performance: how did the weapon or vehicle's performance compare to the space required on the available lift it used? By this criterion, the study examined the value of equipment such a jeep, and what that jeep provided the airborne force considering that it took the space of twelve soldiers on the glider.

Once these relative operational values were applied to the weapons and equipment delivered by the glider, a SUE was determined for each. Figure 3-1 shows the SUEs developed for each.

The 12-man rifle squad in infantry organizations forms the base for the Standard Unit Equivalent (SUE) measurement tool. This measurement was converted to an 11-man squad in the British organization. The rifle squad was considered the smallest tactical element capable of fighting alone in an airborne unit. Accordingly, it is the standard of measure for determining the relative value of the other systems employed in an airborne assault.

The other human element used as a measurment tool is the 5-man support element employed by other than infantry formations. An example of this type of element, also having a SUE of 1.Ø, is the 5-man artillery crew for the 75mm howitzer. This is to represent a relative combat value equal to that of the rifle squad. The reason these elements were assigned a SUE of one was the review of after-action reports reflecting commander assessment of the utility of other than infantry formations. In almost universal application, the other than infantry elements were included in initial assault formations because they were critical to fire support, communication, signal, or medical functions. These combat support functions were viewed as so critical to the airborne operation that rifle squads were deleted from manifest and replaced with the other assets. The weapons systems in the table also reflect this methodology.

Table 3-1. -- Standard Unit Equivalents (SUE)

Equipment	Standard Unit Equivalents (SUE)
12-man squad(infantry type unit)	1.Ø
5-man team, crew(artillery,support)	1.Ø
1/4 ton jeep, scout car	1.5
75mm pack howitzer	3.Ø
AT weapons	2.Ø
heavy machine -gun	Ø.5
1/4-ton trailer, motorcycle	Ø.5

Note: Many other types of equipment were flown in gliders such as demolition material, fuel, and food, but Table 3-1 shows the major combat equipment used for this study.

While the SUEs provided a common basis for comparison between what the gliders delivered and what the parachutes delivered, the cost element needed further examination to determine which elements of cost would be used to determine cost effectiveness. The size and type of various expenditures were studied to decide which expenditures for the Market operation were applicable to this study. The study determined that in an airborne operation the size of Market, a few areas contributed to the majority of the costs. These major areas were:

1. Capital costs of parachutes.
2. Capital costs of gliders.
3. Cost of training parachutists.
4. Cost of training glider pilots.

5. Cost of assembling gliders used for Market (applicable only to glider echelons).

6. Cost of packing personnel parachutes (applicable only to parachute echelons).

7. Costs of replacing gliders not recovered after the operation.

8. Costs of replacing parachutes not recovered after the operation.

Determining the costs

Costs of parachutes

The capital costs of parachutes were selected because parachutes are the essential pieces of airborne equipment for parachutists. It was the major system for parachute delivery of airborne divisions assaulting into Market. The cost used for the American T-7 personnel parachute with reserve was $288.ØØ. The cost of the reserve alone was $92.ØØ.[2] The T-7 was used by the U.S. units. The British units used the X-type parachute without a reserve. The cost of the X-type parachute was sixty British Pounds.[3] This was converted to 1942 U.S. dollars at an official exchange rate of $4.Ø3.[4] At this rate of exchange, the British parachute costs $241.8Ø U.S. then-dollars.

Costs of gliders

The capital costs of the gliders used during the Market operation was established as $19.367.ØØ.[5] This was the average cost of a Waco built CG-4A glider. The costs established for the British Horsa II and the British Hamilcar were derived from determining the average cost per pound of the Waco CG-4A and applying it to the empty gross

weights of the Horsa II and the Hamilcar. This method was selected for the British gliders because inquiries of the Imperial War Museum and the RAF's museum in London produced only one brief reference to a Horsa costing about $40,000. The costs used are $47,039.40 for the Horsa II and $101,160.00 for the Hamilcar. These costs used a capital cost per airframe pound of $5.62. The Waco glider cost was selected as representative of the gliders used at Market although the research could not accurately identify the exact manufacture of the ones used for the operation. Although most CG-4A gliders were called Wacos whether Waco made them or not, the term "Waco" was universally applied to the CG-4A. Waco was the chief contractor and provided inspectors for all makers of the CG-4A and charged the other makers $250 per glider for initial production runs. The Army's plan to provide master jigs to standardize all CG-4A production failed because glider makers were given the go ahead in the urgency to field CG-4As. Consequently, costs soared.

If the manufacturers of the CG-4A who produced more than 1,000 were selected, the costs for the Ford, Gibson, and Ridgefield gliders would be averaged to a cost of $23,895.00 per CG-4A. If the top six manufacturers were selected, the Waco-made glider would be included, but the average cost of a CG-4A would be $23,304.66. If however, all 16 manufacturers of the CG-4A were selected and the average of their costs to the government were used, including the National $1,741,809 glider, the average cost of a CG-4A glider would be $159,754.12.[6] This capital cost exceeded most combat aircraft costs in World War II. For this study, examination determined that the Waco cost

most coincided with a typical cost for a CG-4A. Therefore, the $19,367 amount is used in this study with the corresponding costs for the British gliders. Both U.S. and British gliders were expensive aircraft to buy despite their low operating costs.

The costs for parachutists

The costs for training for parachutists were developed by examining all elements of the parachute training for the U.S. and British paratroopers and selecting an element of cost applicable to this study. The cost was determined by selecting an element common to both the training of paracnutists and glider pilots and then developing a formula that would give a cost figure. The common element in both the training of the parachutist and the glider pilot was flight hours. For the parachutist, the flight hours during his training for the five qualifying jumps before earning his wings was used. For the glider pilot it was the flight hours applied to his training culminating in earning his wings. This was the one training cost most suitable to quantify.

In the case of the parachutists, a dollar amount of $100 per flight hour was assigned to his training in jump school. This amount was selected to represent operation and support costs, maintenance costs, and the crew costs per parachutist. This amount was then multiplied by the number of jumps a student made to qualify in training as a parachutist(five), and then this figure was multiplied times the flight time per jump (.7 hour). This dollar value represented a cost per parachutist for training. This cost element was then applied to determine a cost for the Market operation.

The average flight time for the parachute echelons to reach their drop zones in Market was 3.5 hours. The average expected operational service life of a parachutist was determined as 2.14 combat assaults. In other words, this study uses 2.14 combat parachutist assaults as a service use of a parachutist. This value was then divided into the training cost element to give a dollar amount per parachutist for Market.

Figure 3-2. --Parachute Training Costs(United States)

$100 per flight hr X 5 qualifying jumps at .7 hour per jump = $350
3.5(Market flight) X 2.14(operational life) =7.5
$350 divided by 7.5 equals $46.66 per parachutist.

Figure 3-3.-- Parachute Training Cost(British)

$100 per flight hr X 2 jumps $140 at .7 per jump($100 X 1.4)
3.5(Market flight) X 2.14 Jumps(operational life)

$140 divided by 7.5 equals $18.66 per parachutist for Market

The training cost per U.S. parachutist in Market was $46.66. This same cost formula was applied to the British parachutist, but with a slight variation. The British training of parachutists was conducted differently than in the United States. The British Airborne Forces Depot formed at Hardrick Hall, England in 1942. Its mission was to raise and train the British First Airborne Division. The division's battalions were initially formed into the Parachute Regiment under the Army Air Corps. This regiment formed in August of 1942. The first division combat

assault was in North Africa on 12 November 1942. The Airborne Forces Depot raised one other British airborne division, the Sixth, and helped train units such as the Polish Parachute Brigade which participated in Market(D+1), and then the Depot trained individual replacements.[7] What was unique in the British training system however, was the practice of using a tethered balloon to train parachutists. This too, was a cost effective measure because it freed aircraft for other missions. Normally, the first three of five qualifying jumps was made from a balloon. If aircraft were available, students would jump from aircraft. For this study, the first three qualifying jumps were considered to have been from balloons. Accordingly, the British training costs were less than the U.S. costs for this element.

The costs for glider pilots

The training cost for glider pilots was determined in a similar method. The $100 value per flight hour was used. This figure represents the operational and support costs, maintenance and other costs of training the glider pilots. The flight hour requirement is averaged from the Class A and Class B instruction in the U.S. school and an estimate of the hours other than outside of the glider training regiment with the British. The hour figure was determined as fifty hours per student.

The same average flight duration of 3.5 hour for Market applied to the glider pilots as it did with the parachutists. The operational service life of a glider pilot was determined as between two and four combat missions, as was the case with the parachutists. When using the

training cost formula for the glider pilots, the costs were developed as shown in figure 3-4.

Figure 3-4. -- Glider Pilot Training Cost

$100 per flight hr X 50 hours(average training hours) = $500 divided by 3.5 hr(Market flight time) X 2.14(Operational life) = $500 divided by 7.5 = $666.66 training cost per glider pilot for Market.

Costs of assembling gliders

The next cost element of the cost effectiveness model is the assembly cost of the gliders. This element applied to the U.S glider echelons only, but was a significant expenditure to warrant consideration in this study. During Market, ninety percent of the U.S gliders were assembled from crates in a labor intensive effort almost a month prior to the operation. This was the result of a glider shortage following the Normandy invasion. Crated gliders were shipped from the U.S to meet the Market mission.

The U.S. 26th Mobile Repair and Reclamation Squadron, based at Cookham Common in England was assigned the mission of assembling gliders. By 1 July 1944, it had only assembled 1,045 CG-4A, about enough for one glider echelon of one division.[8]

The 26th, using twenty-six officers and 900 men from 8 August to 15 September, had assembled 2,160 gliders. The men worked in three shifts and used assembly line procedures. They assembled sixty gliders a day as an average, but once even assembled 100 gliders in a single day.[9] To assign a cost to this assembly effort, this study assumed that one shift included 300 soldiers and nine officers. This one shift

assembled twenty CG-4A gliders in an eight-hour shift. In man-hours, this assembly effort equals 2,472 for one shift. Using man-hours without assigning a dollar amount gave a value for comparison. Another technique involved applying World War II pay scales to the assembly effort. In this estimate, the study used the approximate pay grades in a shift multiplied by the number of those pay grades present in a shift. This gave an hourly wage for the glider assembly effort. The calculation in then-dollars was used in comparison with the packing of personnel parachutes.

Costs of packing parachutes

The parachute echelons had no glider assembly effort to use as a cost comparison, but did have an equally labor-intensive, people-driven effort to prepare for Market. The parachute echelons had to pack their parachutes for use in Market. The packing effort preceded every major airborne operation and Market was no exception. Even though every parachutist was trained in packing a parachute, by the time of Market, the airborne division had formed provisional parachute maintenance companies using rigger-trained personnel from the battalions and regiments. Each battalion and regiment was authorized a number of riggers or individuals qualified as riggers. Following Normandy, the divisions had consolidated these people to maximize the number of parachutes that could be packed and to provide a badly needed quality control function to the parachute packing effort.[10]

The packing of a parachute generally required two or three men. One or two riggers would pack and a third individual, usually an

officer, would inspect the parachute. The packing of one parachute averaged 15 minutes. Considering that two soldiers were involved, the man-hour requirement was .5 per parachute. Using a method similar to the one used in assembling gliders, the parachute packing shift involved an estimated 1ØØ soldiers organized as shown in table 3-2.

Table 3-2. -- Parachute Packing Shift(1ØØ-man)

Number	Pay grade	Monthly Pay	Hourly Pay	8 Hour Pay
1	Ø-3	$166.67	.68	$5.44
25	E-5	$ 6Ø.ØØ	.24	$1.92
4	Ø-2	$125.ØØ	.51	$4.Ø8
7Ø	E-3	$36.ØØ	.14	$1.12

Costs of replacing unrecovered gliders

Considering the huge effort that went into packing parachutes and assembling gliders for Market and most major airborne operations, a casual observer would assume an equally huge effort would have gone into the recovery of gliders and parachutes after an operation. The cost associated with replacing total losses of these systems are critical to this study.

The number of gliders employed in Market, both U.S. and British, for the entire operation was 2,613. The total number recovered as of 22 December 1944 was 35Ø.[11] The recovery rate from this number was 13.2 percent for the gliders. This figure is misleading however, as many gliders were intact and serviceable following an assault, but were

later destroyed by enemy artillery fire or damaged by friendly troops. The data for the first day of Market will show the numbers of gliders that landed in a serviceable condition. The situation of the ground combat or availability of aircraft to recover the gliders or the lack of glider pilots prevented this from happening. Applicable to this study in confirming the 13.2 percent recovery rate used was another large airborne operation conducted after Market. This large operation, called Operation Varsity was conducted in March of 1945.

Varsity was an airborne assault across the Rhine river into Germany. Because of the losses during Market, a plan was established to conduct immediate battlefield repair of the gliders and recover them across to the west bank of the Rhine for movement to the rear.[12] It was an ambitious operation with cost effectiveness in mind. A total of 889 U.S. gliders were used in the operation. Of these, 148 or 16.6 percent were recovered. Also, glider pilots were instructed to salvage serviceable spare parts off damaged gliders. The results of this were the recovery of forty-seven truckloads of spare parts and thirty 1-ton trailer loads including 2,000 flight instruments and 1,273 tire and wheel assemblies. The British were less successful.

A total of 416 British gliders were used, and only twenty-four were recovered for a recovery rate of 5.8 percent. For the damaged gliders, only instruments were recovered from the Horsas as the Ministry of Air Production did not use other assemblies from damaged Horsas. For the Hamilcar however, major assemblies were recovered. The British usually jettisoned their tow ropes, so no tow ropes were recovered. The U.S. glider pilots did recover many of their tow ropes.

A total of 889 tow ropes of 350-foot length were used. Of these, 360 were recovered with 288 still serviceable. The recovery rate for tow ropes was 32.4 percent. Also, 296 tow ropes of seventy-five foot length were used. These were for the double tow and ninety of these were recovered with seventy-two serviceable for a recovery rate of 24.3 percent.[13] Because of conditions of the landing zones for the British, the gliders recovered had to be dismantled and trucked to a suitable field for towing out. Parachute recovery was even less coordinated.

Costs of unrecovered parachutes

Both the U.S. and British recovered parachutes through ground salvage means with no special organization established. The U.S. parachutes were supposed to end up in England with the 334th or 490th Quartermaster Companies. The British parachutes were shipped to RAF Station, Cardington.[14] For this study, recovery rates of sixty percent for the U.S. T-7 main parachute and seventy percent for the U.S. reserve parachute were used. For the British X-type parachute, a recovery rate of sixty-five percent was used. Of note in the Varsity report, was the conclusion regarding the glider pilot's recovery efforts. Even though doctrine had been establish for the glider pilot's role, mission, and function by 1945, apparently the glider pilot's recovery efforts were deemed too ambitious. The conclusion in the Varsity report was for glider pilots to, "immediately upon landing... fight the enemy - not initiate salvage operations or guard equipment."[15] The Varsity operation was supposed to have the benefit of lessons learned during Market.

In regard to recovery of gliders during Market, planners at First Allied Airborne Army predicted total loss of gliders as occurring at a "very high rate."[16] The G-4 of the First Allied Airborne Army predicted losses at 1,800 gliders. In planning, he estimated that the minimum time for shipment of a glider from the Port of Embarkation (POE) in the United States was five weeks with several hundred awaiting shipment from the POE. [17] British production would leveled at a rate of 100 gliders per month, not enough to keep up with the rate of loss.[18] The next element of cost is crew pay and parachute pay.

Costs of glider pilot pay

In examining the elements of cost in regard to an airborne operation, two major areas of soldier pay enter the cost effectiveness equation. These two elements of soldier pay are the parachute hazardous duty pay entitled to the parachute troops, and the total crew pay entitled to the glider pilots. These two areas were selected because they are additional expenditures outside of the normal regular military compensation of the soldiers involved. The methodology in this study applies to the annual pay of both group; the glider pilot's annual crew pay, and the parachutists annual parachute pay. Although authorized hazardous duty pay in September of 1944, the glidertroops participating in Market did not receive it for the pay period during Market.

The pay for glider pilots was established using pay tables from the documented pay tables from World War II.[19] These tables were then applied to a typical glider unit organization. Although a glider unit TO&E was available, a interview with Doug Wilmer, author of the "Glider

Soldier" column in Static Line, and S. Tipton Randolph, Secretary of the Glider Pilots Association, confirmed the table used in this study. This was required because of the number of commissions handed out to the flight officers by 1944.[20] The crew pay used in this study is shown in Table 3-3.

Table 3-3.--Glider Pilot Crew Pay

Pay Grade	Monthly Base Pay	Monthly Flight Pay	Annual crew pay
Major Ø-4	$210.ØØ[a]	$105.ØØ	$3780.ØØ
Captain Ø-3	$166.66[b]	$83.33	$3ØØØ.ØØ
Lieutenant Ø-2	$125.ØØ	$62.5Ø	$225Ø.ØØ
Flight Officer	$148.ØØ[c]	$74.ØØ	$2664.ØØ

Note: Committee on Military Affairs, "Flying Duty Pay and Allowances," authorized officers on flight duty received 5Ø percent of their base pay as flight pay, 179.

[a]Committee on Military Affairs, Table F-1-a, Major less than 14 years of service.

[b] Ibid, Captain less than 7 years of service.

[c]Committee on Military Affairs, Table D-1-a, Warrant officers other than Army Mine Planter Service, Flight Officer less than 4 years of service.

Costs of parachute pay

Parachute pay for the parachutists used a simplified formula. In World War II, officers received $1ØØ.ØØ per month as hazardous duty pay for conducting frequent parachute jumps. Enlisted soldiers received $55.ØØ per month. Using these costs, it was assumed that fifteen percent of the parachutists were officers and entitled to the officer rate and the other eighty-five percent would receive the enlisted rate.

Now that all of the elements of cost effectiveness have been identified, the study will examine the glider and parachute echelons one division at a time.

ENDNOTES

[1]James M. Gavin, Airborne Warfare, (Washington: Infantry Journal Press, 1947), 141.

[2]United States Army Air Forces, Illustrtated Catalog of Clothing and Equipment, September 30, 1943, 13

[3]Gregor Ferguson, The Paras: British Airborne Forces 1940-1984, (London: Osprey Publishing, 1984), 4.

[4]Department of Commerce, Statistical Abstract of the United States, (Washington: Government Printing Office,1942), 323.

[5]James E. Mrazek, Fighting Gliders of World War II, (New York: St. Martin's Press, 1977), Appendix III.

[6]Ibid.

[7]Ferguson, The Paras: British Airborne Forces 1940-1984, 10.

[8]Gerald E. Devlin, Silent Wings, with a foreward by General William C. Westmoreland(New York: St. Martin's Press, 1985), 245

[9]Ibid. , 244.

[10]Arnold Moen, parachute officer with 82nd Airborne Division, 1942-1945, Telephone interview with author, 5 January 1991.

[11]War Department, 1st Allied Airborne Operations in Holland, Sep-Nov 44(Market), Headquarters, 1st AAA, APO 740, 22 December 1944, 25.

[12]War Department, "Report of Operation Varsity," Headquarters, 1st Allied Airborne Army, APO 740, 19 May 1945, 48.

[13]Ibid. , 48.

[14]Ibid. , 49.

[15]Ibid. , 49.

[16]J.H. Whalley-Kelly, Assistant Chief of Staff, G-4, 1st Allied Airborne Army, Airborne memorandum to Lieutenant Colonel Birnbaum, Deputy Chief of Staff(Plans), 1st Allied Army, subject: "Status of Aircraft on Hand," 18 August 1944, 1.

[17]Ibid. , Enclosure "B".

[18]Ibid. , 3.

[19]Committee on Military Affairs, 76th Congress, Washington: Government Printing Office, 1940.

[20]S. Tipton Randolph, National World War II Glider Pilots Association, Telephone interview with author, 9 January, 1991, Freehold, New Jersey.

CHAPTER FOUR

GLIDER AND PARACHUTE ECHELON ANALYSIS

This chapter will examine each division's glider and parachute echelon for 17 September 1944. The five elements for each are included in tables followed by tables with the SUE comparisons. The mission of each division is included as background to the analysis.

COSTS OF THE 101st AIRBORNE DIVISION

Mission of the division

> 101st Airborne Division will land units in the general area south of UDEN, seize and hold highway crossings near NEERPELT (3596), VALKENSWAARD (4007), EINDHOVEN (4318), SON (4425), ST. OEDENRODE (4232), VEGHEL (4938), and UDEN (5343), and insure the advance of the Second British Army.[1]

Factors affecting organization of glider and parachute echelons

General Maxwell D. Taylor organized his available lift to provide mobility to his division when it landed. General Taylor did not bring his artillery on the first lifts because he believed he could use the British artillery advancing as part of Garden. The linkup was supposed to take place in eight hours.[2]

Table 4-1.-- Glider echelon organization(101st Airborne)

UNIT	NUMBER OF GLIDERS	NUMBER OF TROOPS	NUMBER OF WPNS, EQUIP	SUE
HHC, 101 ABN	8 x CG-4A	44 + 8 pilots	4 x Jeeps, 1 x Trl	15.9
501 Para Inf Regt	8 x CG-4A	27 + 8 pilots	8 x Jeeps, 1 x 37mm AT	16.9
502 Para Inf Regt	8 x CG-4A	22 + 8 pilots	5 x Jeeps, 3 x Trls, .50 cal	12.0
506 Para Inf Regt	8 x CG-4A	18 + 8 pilots	6 x Jeeps, 2 x Trls,2 x.50	13.1
101 Arty	3 x CG-4A	28 + 3 pilots	1 x Jeep	7.7
326 Medical	6 x CG-4A	52 + 6 pilots	2 x Jeeps, 2 x Trls	14.9
101 Signal	14 x CG-4A	60 +14 pilots	5 x Jeeps, 3 x Trls	20.5
101 Recon	15 x CG-4A	60 +15 pilots	12 x Jeeps, 2 x Trls	25.0
TOTALS	70 x CG-4A	311+70 pilots	43 Jeeps, 18 Trls	126.0

Table 4-2.-- 101st Glider Echelon Reaching LZ

UNIT	A.	B.	C.	D.	E.	F.	G.	H.	S.U.E
HHC 101	8	7	1	Ø	Ø	Ø	40	4/1	15.1
501 PIR	8	7	1	Ø	Ø	Ø	23	7/Ø	15.2
502 PIR	8	7	1	Ø	Ø	Ø	18	4/3	9.6
506 PIR	8	6	Ø	Ø	2	Ø	17	4/2	8.9
101 Arty	3	3	Ø	Ø	Ø	Ø	29	1	7.5
326 MED	6	6	Ø	Ø	Ø	Ø	52	2/2	14.9
101 SIG	11	9	Ø	Ø	2	Ø	39	5/3	17.6
101 recon	15	8	Ø	2	Ø	2	34	5/2	11.9
Total	67	53	3	2	4	2	252	32/13	88.8

Note: Guide to Table 4-2.

A. Number of gliders taking off from England

B. Number of gliders landing on LZ without incident

C. Number of gliders crash landing on LZ

D. Number of gliders landing in England

E. Number of gliders landing in enemy territory(linked up at D+2)

F. Number of gliders unaccounted for(Tugs shot down)

G. Number of troops landed safely on LZ

H. Number of Jeeps/Trailers delivered safely to LZ

I. Number of Standard Unit Equivalents (SUE)

Capital Costs, Gliders 101st Airborne Division

Seventy x CG-4A at $19367 each = $1,355,690

Fifty-three x CG-4A at $19,367 each = $1,026,451

Glider Assembly Costs 101st Airborne Division

Seventy x CG-4A assembled using 300-man 8-hour shift.

Twenty gliders per shift = (28 hours x 300 men)= 8,400 Man-hours

Glider Pilot Training Costs 101st Airborne Division

Seventy glider pilots(flew single pilot) at $666.66 per pilot (70 x $666.66) = $46,666.20

Glider Recovery Costs 101st Airborne Division

Fifty-three gliders land without incident; 13.2 percent are recovered end of Market =

seven CG-4As recoverable, the other forty-six are total loss, cost(46 x 19,367 = $890,882.

Probable recoverable gliders at end of first day assuming ten percent damage of the fifty-three that landed safely on LZ = forty-eight recoverable; five in England recoverable; = the following gliders:

Fifty-three recoverable(total loss of 17) 17 x $19,367 = $329,239

Crew Pay Costs 101st Airborne Division

Seventy glider pilots at the following grade structure:

1 x 0-4 = $3,780(1 x 3,780) =$3,780

5 x 0-3 = $3,000(5 x 3,000) =$15,000

20 x 0-2= $2,250(20 x 2,250) = $45,000

44 x Flight Officers = $2,664(44 x 2,664) = $117,216

TOTAL: $180,996

Parachute Echelon 101st Airborne Division

Table 4-3. --Organization of Parachute Echelon 101st Airborne

UNIT	Number of jumpers on board	Number of jumpers who jumped	Significant incident numbers	SUE
CMD GRP 101 ABN	19	19	0	3.8
HHC 101 ABN	18	18	0	3.6
101 MP CO	29	29	0	5.8
501 PIR	1967	1958	30 jump injuries, 3 refusals	163.1
502 PIR	2101	2091	41 jump injuries, 18 shot in a/c	174.2
506 PIR	2190	2183	29 jump injuries, 2 killed by props	181.9
HHB 101 Arty	8	8	0	1.6
326 Eng	252	252	0	21.0
326 MED	2	2	0	.4
426 QM	31	31	0	6.2
TOTAL	6,834	6,809	103	561.6

Capital Costs of parachutes 101st Airborne Division

6,834 x $288 = $1,968,192.00

Training costs of parachutists 101st Airborne Division

6,834 x $46.66 = $318,874.44

Packing costs for parachutes 101st Airborne Division

6,834 main parachutes + 6,834 reserves at .5 man-hours per parachute = 6,834 man-hours

Pay costs of parachute pay for parachute echelon 101st Airborne Division

6,834 parachutists; fifteen percent $110 per month(1025 x $110 = $11,220) $11,220 x 12 months = $134,640.00 annual parachute pay(officers)

5,809 x $55 per month(5,809 x $55 = $319,495.00) $319,495.00 x 12 = $3,833,940 annual parachute pay (enlisted)

Recovery costs parachutes 101st Airborne Division

6,834 main parachutes at sixty percent recovered = 4100 recovered; 2734 total losses at $196 each = $535,864.00

6,834 reserve parachutes at seventy percent recovered = 4783.8 recovered; 2051 total losses at $92 each = $188,692.00

Cost comparison between glider and parachute echelons

Table 4-4.-- Comparison, glider and parachute cost elements

COST ELEMENT	101st Glider Echelon	101st Parachute Echelon
Crew/Parachute Pay	$180,996	$3,833,940
Capital Equipment	$1,355,690	$1,968,192
Training	$46,666	$318,874
Assembling/Packing	8,400 man-hours	6,834 man-hours
Recovering	$890,882	$724,556
TOTAL	$2,474,234 + 8,400 m/h	$3,833,940 + 6,834 m/h

Table 4-5.-- Cost per SUE(cost element divided by total S.U.E. of each echelon)

COST ELEMENT	101st Glider Echelon	101st Parachute Echelon
Crew/Parachute Pay per SUE	$2038.24	$6,826.81
Capital Equipment per SUE	$15,266.77	$3504.61
Training cost to deliver one SUE	$525.51	$567.70
Assembling/Packing cost per SUE	$94.59	$12.16
Recovery cost per SUE	$10,032.45	$1290.16
TOTAL	$27,862.97	$12,189.28

COSTS OF 82ND AIRBORNE DIVISION

Mission of the division

> 82nd U.S. Airborne Division will land by parachute and glider commencing D-day south of Nijmegen; seize and hold the highway bridges across the MAAS River at GRAVES and the WAAL River at NIJMEGEN; seize, organize, and hold the high ground between NIJMEGEN and GROESBEEK; deny the roads in the division area to the enemy and dominate key terrain.[3]

Factors influencing organization of division

General James M. Gavin commanded the 82nd during Market. Based on his assessment of the Normandy landings, he would parachute his forces on top of their objectives.[4] Gavin used his small force of

gliders for delivery of antitank weapons as the first priority as he believed these weapons critical to his mission.

Organization of the glider echelon 82nd Airborne Division 17 September, 1944

Table 4-6.--Glider Echelon Organization(82nd Airborne)

UNIT	NUMBER OF CG-4As	NUMBER OF TROOPS	NUMBER OF WPNS, EQUIP	SUE
A Btry, 80th Antitank Bn.	12	135	8 x 57mm AT, 9 x Jeeps, 2 x trls	58.5
Air Support Party	2	8	1 x Jeep, 1 x Trl	3.7
82nd Arty Hqs	2	8	2 x Jeep	4.7
82nd Recon Co.	6	24	4 x Jeep	8.5
82nd Signal Company	6	24	3 x Jeep, 3 x Trl	11.3
HHC, 82nd ABN	12	48	6 x Jeep, 6 x Trls	22.6
TOTAL	50	247	8 x 57mm,25 Jeeps, 13 Trls	119.7

Table 4-7.-- Results of Glider Echelon(82nd Airborne)

UNIT	A	B	C	D	E	F	SUE
A Btry 80th AT	Ø	Ø	Ø	6	135	8 x 57mm, 5 Jeeps	51.9
Air Spt Party	Ø	Ø	Ø	Ø	8	2 Jeeps	3.7
82nd Arty Hqs	2	Ø	Ø	Ø	Ø	Ø	Ø
82nd Recon	Ø	1	Ø	4	24	1 Jeep. 2 Trls	8.5
82nd Signal	Ø	Ø	2	Ø	Ø	Ø	5.Ø
HHC,82 ABN	Ø	Ø	Ø	4	48	1 Jeep	6.2
TOTAL	2	1	2	14	216	8 x AT, 9 Jeeps, 2 Trl	75.3

Note: The following items explain the columns of table 4-7.

A. Number of Gliders aborting enroute

B. Number of glider shot down over enemy territory

C. Number of gliders destroyed on landing

D. Number of gliders severely damaged on landing

E. Number of troops safely landed on LZ

F. Number of equipment safely on LZ

G. Standard Unit Equivalents (SUE)

Costs of glider echelon, 82nd Airborne Division

Capital Costs for gliders used

Fifty CG-4As x $19,367 = $968,35Ø

Forty-six CG-4As x $19,367 = $89Ø,882

Glider Assembly costs, 82nd Airborne Division

Fifty x CG-4As assembled using 300-man 8-hour shift; 20 gliders per shift.

Twenty hours to assemble fifty CG-4As, at cost of (20 x 300) = 6,000 man-hours

Glider Pilot Training Costs, 82nd Airborne Division

Fifty pilots(flew single pilot) at cost of $666.66 per pilot(50 x $666.66) = $33,333

Glider recovery costs 82nd Airborne Division

Forty of fifty gliders made landing zone, two others destroyed on landing, one shot down in enemy territory(loss), fourteen damaged on landing(assumed non-recoverable); seventeen total losses at $19,367 = $329,239. Added to this figure is the thirteen percent recoverable from remainder = (33 x 13 %) = four gliders recovered. The other twenty-nine were total losses, this means 29(29 x $19,367) + 17(17 x $19,367) = $561,643 + $329,239 = $890,882 total loss to government.

Glider crew pay costs 82nd Airborne Division

Table 4-8.-- Crew Pay Costs(82nd Airborne)

Pay Grade	Number of pilots	Annual Pay	Total Annual by Pay Grade	Percent of pay as flight pay
0-3	3	$3,000	$ 9,000	50 percent
0-2	12	$2,250	$ 27,000	50 percent
Flight Officer	36	$2,664	$ 95,904	50 percent
TOTAL	50	$7,914	$131,904	50 percent

Parachute Echelon Costs 82nd Airborne Division

Table 4-9.-- Organization of Parachute Echelon(82nd Airborne)

UNIT	NUMBER TROOPS DELIVERED	MAJOR EQUIPMENT DELIVERED	SUE
82nd Pathfinders	38	Ø	7.6
Hqs 82nd ABN Div	24	Ø	4.8
5Ø5th PIR	1,91Ø	Ø	159.1
5Ø4th PIR	2,2Ø2	Ø	183.5
5Ø8th PIR	2,196	Ø	183.Ø
3Ø7th Engineers	346	Ø	28.8
376th Para Field Arty Bn	544	12 x 75mm Howitzers	138.8[a]
TOTAL	7,25Ø	12 X 75mm	7Ø5.6

[a]Only 1Ø of the 12 howitzers could be assembled because of parachute loads falling in enemy territory. Telephone interview with Frank D. Boyd, Captain in the 376th during Market, 28 December 199Ø, Overbrook, KS.

Costs of the parachute echelon 82nd Airborne Division

Capital costs of parachutes 82nd Airborne Division

7,25Ø x $288 = $2,Ø88,ØØØ

Cost in Man-hours of parachute packing 82nd Airborne Division

7,25Ø x .5 hr per main parachute = 3,625 man-hours

7,25Ø x .5 hr per reserve parachute = 3,625 man-hours

Cost in training of parachutists 82nd Airborne Division

7,25Ø x $46.66 per parachutist = $338,285

Cost of recovery of parachutes 82nd Airborne

7,250 main parachutes employed; sixty percent recovered = 4350 recovered; 2900 total loss at $196 each = $568,400 total loss cost to government.

7,250 reserve parachutes employed; seventy percent recovered = 5075 recovered; 2175 total loss at $92 each = $200,100 total loss to government.

Total parachute cost = $768,500

Cost of parachute pay for 82nd Airborne

7,250 x fifteen percent officer pay = 1088 officers at $110 per month = $119,680

6162 x $55 per month = $338,910

Total annual parachute pay = $338,910 x 12 = $4,066,920 + $119,680 x 12 = $1,436,160($4,066,920 + $1,436,160) = $5,503,080 total annual parachute pay

Cost comparison between glider and parachute echelons 82nd Airborne

Table 4-10.-- Costs Comparisons(82nd Airborne)

Cost Element	82nd Glider Echelon	82nd Parachute Echelon
Capital Equipment	$968,350	$2,088,000
Training	$33,333	$338,285
Assembly,Packing	6,000 man-hours	3,625 man-hours
Recovery	$890,882	$768,500
Crew/Parachute pay	$131,904	$5,503,080
TOTAL	$2,024,469 6,000 m/hr	$8,697,865 3,625 m/hr

Cost comparison per SUE

Table 4-11.-- Costs Per SUE(82nd Airborne)

COST ELEMENT	GLIDER ELEMENT	PARACHUTE ELEMENT
Capital Cost per SUE	$12,859.80	$2,959.18
Training Cost per SUE	$442.66	$479.42
Assembly/Packing Cost per SUE	$79.60	$479.49
Recovery cost per SUE	$1751.71	$1,089.14
Crew/Parachute pay per SUE	$1,751.71	$7,799.14
TOTAL Cost per SUE	$26,885.37	$12,326.90

COST OF THE BRITISH FIRST AIRBORNE DIVISION

Mission of the 1st British Airborne Division

> The 1st British Airborne Division will land in the vicinity of ARNHEM, seize and hold the river and canal crossings at ARNHEM and establish a sufficient bridgehead for passage of the Second British Army.[5]

Factors affecting organization of glider and parachute echelon

General Robert E. Urquhart commanded the First British Airborne Division. His mission, as he saw it, was to not only seize the bridge at Arnhem, but also to secure his DZs and LZs until his subsequent lifts arrived. As Urquhart division was being employed the deepest into enemy territory, he received a considerable amount of aircraft.[6]

Organization of the glider echelon First Airborne Division

Table 4-12.-- Organization of Glider Echelon(First Airborne)

UNIT	NUMBER OF GLIDERS	NUMBER OF TROOPS LANDED[a]	NUMBER OF WEAPONS and EQUIP	SUE
1st ABN HQS	1Ø x CG-4A	43	1Ø x Jeep, 1Ø Motorcycle	33.4
Recon Sdn	22 x Horsa	227	22 x Jeep	54.6
Light Regiment	57 x Horsa	448	39x Jeep, 15 x Trl	11Ø.2
1st ANTITANK BTY	21 x Horsa	84	21 x 6lb AT gun, 21 Jeep	94.1
17th Para Field Arty	8 x Hamilcar,3 x Horsa	236	16 x 75mm Howz.18x Jeep, 1Ø Trl	129.2
9th Field Co, Royal Engineer	16 x Horsa	11Ø	11 x Jeep 8 x Trl	33.4
1st PARA BDE	3 x Hamilcar, 2Ø x Horsa	139	6 x Sct Car,6 x Jeep	49.6
Hqs, Airland Bde	1Ø x Horsa	85	5 x Jeep, 5 x Trl	28.8
1st Airlanding Bn	1 x Hamilcar, 56 x Horsa	415	2 x Sct Car 15 x Jeep, 1Ø x Trl	78.5
2nd Airlanding Bn	1 x Hamilcar, 56 x Horsa	415	2 x Sct Car, 15 x Jeep, 1Ø x Trl	78.5

Table 4-12. -- Continued

UNIT	NUMBER OF GLIDERS	NUMBER OF TROOPS LANDED[a]	NUMBER OF WEAPONS and EQUIP	SUE
3rd Airlanding	22 x Horsa	36Ø	8 xJeep,8 trl	52.7
181st Airlanding	7 x Horsa	1Ø6	7 x Jeep and 3 Trls	34.4
Adm 1st Abn	7 x Horsa	22	4 x Jeep, 3	13.1
Abn Corps	38 x Horsa	228	35 Jeep, 35	122.5
TOTAL	358	2,9Ø8	216 x Jeep, 1Ø7 Trl, 1Ø x Sct Car, 16 x Howz,1Ø x M.C., 18 x	884.8

[a]Glider pilots included in eleven-man squad count, two pilots per glider.

Capital Costs of British First Airborne Division Gliders

All of the First Airborne's gliders reached the LZ, thirty-nine of the gliders were released early , but the cargo reached the LZ.

345 Horsa II x $47,Ø39 = $16,228,455

13 Hamilcar x $1Ø1,16Ø = $1,315,Ø8Ø

Costs of Glider Assembly First Airborne Division

These costs were not applicable.

Costs of Glider Recovery

345 x 13 percent recovered = forty-five Horsa recovered(total loss of 300 at $14,111,700)

13 x 13 percent recovered = two Hamilcar recovered(total loss of eleven at $1,112,760)

Total cost to government = $15,224,460

Cost of Crew Pay for Glider Pilots(Same formula as applied to U.S.)

358 x 2(dual pilot) = 716 paid flyers(ten percent 0-2 equivalent, 90 percent flying sergeants,paid at 1/2 rate of US. Flight officer).

72 x $2,250 = $162,000 x 12 = $1,944,000

286 x $1332 x 12 = $15,984

Total crew pay = $1,959,984

Cost of Training for glider pilots First British Airborne Division

British glider pilots received eight weeks of light plane flying, this is assumed to increase the cost by $1,000. Each glider pilot cost $1,666.66 to train.

716 x $1,666.66 = $1,193,328.50

Costs of the Parachute Echelon

Table 4-13.-- Parachute Echelon SUE(First Airborne)

UNIT	TROOPS DELIVERED	SUE
12th IND PARA CO.	210	19.0
1st BN Para Bde	510	46.3
2nd BN Para Bde	510	46.3
3rd BN Para Bde	510	46.3
1st BN Royal Eng	222	20.1
Para Bde Hqs	120	24.0
4 Admin Company	56	11.2
1st Para Div Hqs	85	17.0
Recon Sdn	180	16.3
TOTAL	2,283	246.5

Capital Costs of Parachutes First British Airborne Division

2,283 x $241.8Ø(reserves not used) = $552,Ø29.4Ø

Costs to Train British Parachutists

2,283 parachutists x $18.66 per British parachutist = $42,6ØØ

Costs of Recovery for British Parachutes(65 percent)

2,283 x 65 percent =1483 recovered(8ØØ total loss at $241.8Ø each)

Total loss to government = $193,44Ø

Costs of Parachute Pay For British Parachutist

2,283 x 15 percent at officer rate = 342 x $11Ø = $37,62Ø(x 12 for annual pay)

1941 x $55 at enlisted rate = 1941 x $55 = $1Ø6,755) x 12 for annual pay= $451,44Ø + $1,281,Ø6Ø = $1,732,5ØØ total annual parachute pay

Costs to Pack Parachutes 1st British Airborne

2,283 x .5 man-hour per parachute = 1141.5 man-hours

Comparison Between Parachute and Glider Echelons

Table 4-14.--Comparison between echelons of First Airborne Division

COST ELEMENT	GLIDER ECHELON	PARACHUTE ECHELON
CAPITAL COST	$17,543,535	$552,Ø29
TRAINING COST	$ 1,193,328	$ 46,6ØØ
RECOVERY COST	$15,224,46Ø	$193,44Ø
ASSEMBLY/PACK COST	N/A	1141.5 man-hours
CREW/PARACHUTE PAY	$1,959,984	$1,732,5ØØ
TOTAL	$35,921,3Ø7	$2,524,569 1141.5 m/hr

Comparison Between Parachute and Glider SUE

Table 4-15. -- Comparison of SUE(First Airborne)

COST ELEMENT	GLIDER ECHELON	PARACHUTE ECHELON
Capital Cost per SUE	$19,827.68	$2,239.47
Training Cost per S.U.E.	$1,348.65	$189.Ø4
Recovery Cost per S.U.E.	$17,2Ø6.66	$784.74
Assembly/Pack Cost per S.U.E.	Ø	4.6 man-hours
Crew/Parachute Pay Cost per S.U.E.	$2,215.17	$7,Ø28.39
TOTAL	$4Ø,598.16	$1Ø,241.64

Summary of Costs

Table 4-16.-- Costs per division for all five elements per SUE

UNIT	GLIDER	PARACHUTE
1Ø1st Airborne	$27,862.91 and 94.59 man-hours	$12,189.28 and 12.16 man-hours
82nd Airborne	$26,885.37 and 79.6 man-hours	$12,326.9Ø and 1Ø.27 man-hours
British 1st Airborne	$4Ø,598.16	$1Ø,241.64 and 4.6 man-hours
Total	$95,346.44 and 174.19 man-hours	$34,757.85 and 27.Ø3 man-hours

ENDNOTES

[1]War Department, "Field Order Number 11," Operation Market, Headquarters, 101st Airborne Divsion, 13 September 1944, 3.

[2]Cornelius Ryan, A Bridge Too Far, (New York: Popular Library, 1977), 217.

[3]War Department, "Field Order Number 11," Operation Market, Headquarters, 82nd Airborne Division, APO 469, 13 September 1944, 3.

[4]Cornelius Ryan, A Bridge Too Far, New York: Popular Library, 1977, 108.

[5]War Department, "Field Order Number 11," Operation Market, 1st Allied Army, 13 September 1944.

[6]Ryan, A Bridge Too Far, 112.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Answering the Research Question

The research question posed in the introduction to this study asked whether gliders were cost effective compared to parachutes on 17 September 1944 during the Market airborne operation. The research question's framework used the five elements of cost selected as a means of measuring cost effectiveness.

The five elements were equipment, training, assembly or packing, pay, and recovery. Given these five elements, gliders were not cost effective on 17 September 1944. The analysis shows gliders were almost two and one-half times more costly than parachutes for the United States' 82nd and 101st Airborne divisions, and almost four times more costly in the British First Airborne division and corps headquarters units.

This is a simple answer to a complex question of cost effectiveness. While gliders, in this one airborne laboratory were not cost effective, the cost elements clearly point to areas that could have been improved. For each of the elements of cost, a more detailed conclusion for each division is instructive.

Conclusions for the 101st Airborne Division

Equipment

Gliders were an expensive tool. Almost three times as much of the cost elements was spent equipping the same SUE for glider assault. Clearly, the added mobility and firepower carried by the gliders still could not increase the number of SUEs to represent the glider as more cost effective than the parachute.

The parachute, as used by the 101st on 17 September 1944, represented an inexpensive, reliable system for airborne assault. The requirement to deliver a large number of troops was met most effectively, from a cost of equipping view, by the T-7 parachute and reserve.

Training

The glider provided a more cost effective means of training for airborne assault. This resulted from the small number of glider pilots needed to support the 101st glider echelon compared to the requirement to have qualified parachutists for the parachute echelon. Glider pilots could be trained at a considerable savings over the costs of training each paratrooper to perform as a parachutist.

In the 101st glider echelon, the main reason for training favoring the glider was single-pilot gliders. Because of the severe shortage of glider pilots, the 101st gliders were flown with only one rated pilot. The CG-4A called for two pilots, but the 17 September missions were flown with one rated pilot at the controls because of the pilot shortage described in Chapter Two.

Assembly and Packing

The glider echelon required almost eight times as much manpower effort for this cost element. Even though the packing of parachutes was tedious and time consuming, it was insignificant compared to the Herculean effort required to assemble gliders. The assembly line procedures used for the CG-4A gliders prior to Market resulted from poor attempts to recover gliders earlier.

Pay

Glider pilot pay was considerably less for the glider echelon than parachute pay was for the parachute echelon. The parachute pay alone for the 101st was three and one-half times more than the total pay for the glider pilots. Paying glider pilots was more cost effective than paying parachutists for the same combat power delivered.

Recovery

The recovery of parachutes and gliders was poor. Accordingly, the replacement costs for both were high. From a cost effectiveness view however, gliders were more expensive to replace. For the 101st, gliders were almost eight times more costly to replace than parachutes.

Conclusions for the 82nd Airborne Division

Equipment

As with the 101st, equipping the glider echelon was more costly than equipping the parachute echelon. In the 82nd, the glider echelon cost almost four and one-half times more to equip than the parachute echelon. Cost effectiveness then, favors the parachute in this example.

The disparity between the 82nd and the 101st is because the 101st loaded more SUEs on its glider echelon, specifically artillery. The conclusion is, with the expense of the glider, the greater load it can carry for combat power on the ground, the greater its cost effectiveness.

Training

The conclusions for training are almost identical for the 82nd and the 101st. Again, using single-pilot gliders resulted in a more effective approach to airborne assault. The small number of glider pilots used to deliver a large number of troops and equipment with the attendant value in SUEs indicates it was more cost effective to train the glider pilots than the parachutists.

Assembly and Packing

Identical to the 101st, the assembly of gliders for the 82nd required eight times as much manpower as that required for the packing of parachutes to achieve the same relative capability on the ground. The

glider assembly effort required a tremendous amount of work compared to the packing of parachutes.

Pay

Paying the glider pilots cost less than paying the parachutists to achieve the same capability on the ground. For the 82nd, the single-pilot solution assured cost effectiveness. Using only one pilot to fly the gliders demonstrated that under the daylight conditions of Market, it was the most cost effective approach.

Recovery

The same recovery rate for gliders and parachutes as in the 101st resulted in a higher cost for replacing the gliders abandoned during Market. The 82nd made no effort to recover either parachutes or gliders to a rate that would have prevented having to buy them again. The unit did not safeguard or attempt to retrieve either gliders or parachutes on 17 September 1944.

Conclusions for the British 1st Airborne

Equipment

British gliders, although more capable in delivering payload than U.S. gliders, were nine times more costly to employ than parachutes to achieve the same capability on the ground. The reason for this was the attendant higher cost per glider for the Horsa II and Hamilcar. British gliders also were compared against the reliable British X-type parachute.

This parachute was more cost effective because it was lower in price, used no reserve, and was highly reliable. The obvious conclusion is that reserve parachutes not only increase cost with no increase in capability, but the reserve parachute may have psychological effectiveness instead of cost effectiveness.

Training

The British approach to training glider pilots as thoroughly as powered pilots drove the costs of their training to a level comparable to that or greater than any rated aviator in the RAF. When this is compared to the training of parachutists qualified from balloons, the British glider pilot program was not cost effective.

The same capability for delivering combat power to the ground could be achieved at cost almost seven times less by training parachutists. This was particularly true considering the British use of balloons, and the balloon's low cost as a training device, when compared to the cost of training the British glider pilot who could perform many missions such as powered pilot or infantryman.

Assembly and Packing

The British glider echelons launching their assault during Market were fortunate in that their gliders were delivered with no assembly required. The British parachute packing effort was also smaller than the U.S. effort because the reserve parachute was not used, so only half as many parachutes needed to be packed compared with the U.S. main and reserve parachutes.

Pay

The British crews during Market flew with two rated glider pilots at the controls. Accordingly, the glider pilot pay was greater than in the U.S. glider echelons. Even with two pilots per glider however, the parachute pay was three and one-half times more costly than glider pilot pay to achieve the same capability on the ground.

From a cost effective view considering pay, the glider pilot was clearly more cost effective. The reason for this in the First Airborne division was the thousands of parachutists receiving jump pay compared with the several hundred glider pilots, many of whom were NCOs.

Cost Effective Summary

Lord Kelvin once observed, "Large increases in cost with questionable increases in performance can be tolerated only for race horses and fancy women."[1] Perhaps gliders fall under Kelvin's remark too, when seen across all five elements of cost used in this study, but several salient issues surface from glider and parachute employment on 17 September 1944.

Most important were the related issues of equipping and recovering the glider force. Gliders were treated as expendable aircraft during the assault phase of the airborne operation, but transformed into critical recoverable items afterwards. Parachutes similarly suffered the same fate. The difference was the capital costs for the gliders. Gliders cost too much for a single use. If gliders were truly a single-use aircraft, then they should have been designed with only one assault in mind. This was not done.

If however, gliders were envisioned as multiple mission assault aircraft, the recovery rates should have been higher in an attempt to return many gliders to service as possible. This did not happen as many gliders were abandoned on landing zones and others destroyed by friendly troops or enemy action. The solution would have been a concerted, coordinated attempt to immediately recover as many gliders as the tactical situation allowed. The recovery of only 350 gliders from the entire Market operation points to this deficiency. Gliders were too expensive to leave behind.

Many parachutes were left behind also, but a significant conclusion from the British use of the X-type parachute can be made. This parachute was more cost effective than the U.S. T-7 parachute and its reserve. The conclusion is that a single, highly reliable personnel parachute is more cost effective than a main and reserve parachute combination.

The issue of training the glider or parachute force from this study provides two straightforward conclusions. First is the single-pilot technique used by the U.S. glider pilots. Although a two-pilot aircraft, the CG-4A was successfully flown, in combat, by a single-pilot. The training implication is obviously that it was more cost effective to single-pilot aircraft during this operation. Second, the British use of balloons to qualify parachutists reduced costs with no apparent decrease in effectiveness.

Regarding the glider assembly and parachute packing, the conclusion is that the assembly of the CG-4As required huge assets in manpower and time. These manpower assets could have contributed to

Market besides putting gliders together. The British, while not having to transport Horsa and Hamilcar gliders from the United States, did have the judgement to assemble their gliders at the factory and test fly them enroute to airborne units.

The conclusion regarding pay is that it cost a lot to have highly qualified individuals for an airborne assault capability. Whether those individuals are a small number of glider pilots or the thousands of troops receiving jump pay is a subject for further study, but in this study the glider pilot was more cost effective in terms of pay.

Although gliders were not found to be cost effective, but this study holds historical, operational, and future significance. These areas contribute to the body of knowledge about airborne operations.

Study Recommendations

The five elements of cost used in this study should be used for accurate measurement of any assault system. While this study focused on a single day of a major airborne operation, the five elements of cost could be applied to any major assault by air, land or sea.

The Standard Unit Equivalent (SUE) be used for study in comparison of weapons systems. The SUE used in this study measured the value of selected weapons systems against the value of a rifle squad. Similar comparisons could be developed from other weapons and assault systems.

The $5,000 glider model described in this study represents a retrospective view of a cost effective system of airborne assault. The lesson for future planners is that a design that accounts for cost and is

capable of providing a tactical use on the ground at lower cost will be more cost effective. If the requirements for gliders could have been formulated early in the war in terms of mission and duration, the $5,000 glider could have been achieved. A clear statement of the required operating capability and capital cost limit is mandatory in any assault system.

Significance of Conclusions

Historical significance

As a review of the tactics and techniques employed by the First Allied Airborne Army during Market, this study reinforced several points.

All three division commanders organized their glider and parachute echelons in accordance with their assigned mission and available aircraft. Major considerations were the expected size of the enemy force on the ground, size of drop and landing zones, and requirements for speed in seizing objectives.

If the British had used its leading glider echelons to land closer to the division's objective of the Arnhem bridges. This was within the capability of the British glider force, and suitable landing zones were available. Selection of landing zones should have received greater attention.

For the U.S. divisions, more artillery could have been delivered on the initial assault. In examining the glider loads of the U.S. 82nd and 101st Airborne divisions, more SUEs could have been achieved by the glider echelons if more artillery went in on September 17th. The

subsequent weather problems prevented a significant amount of combat power from reaching the divisions in time. More SUEs and hence, more combat power could have been delivered by increasing the number of 75mm pack howitzers or 37mm anti-tank weapons going in on the 17th. This would have also been in accordance with guidance from leaders such as General Gavin who gave an order of priority for what types of equipment were important for a glider to carry.

The recovery issue has already been addressed, but deserves mention again here. The Market gliders, most for sound tactical reasons, were essentially abandoned. These same gliders however, became critical to future operations. So critical, that an attempt was made in December of 1944 to retrieve any left in Holland for use in resupplying the trapped paratroopers at Bastogne, Belgium during the German's Ardennes Offensive. Perhaps an effort to recover these gliders earlier would have greater results later than leaving them behind.

Operational Significance

Operationally, this study provides important conclusions for training and equipping airborne forces. In equipment, the lesson is clear. Leaders in airborne units must consider safeguarding parachutes and other pieces of airborne equipment having any potential for future use.

In training, the British use of balloons to qualify parachutists provides an example of a cost effective means to accomplish training. It is important because the same capability was achieved by using balloons as the U.S. achieved by using aircraft. The savings in using balloons

were considerable, and no evidence existed that the British parachutists were any less capable than U.S. parachutists in jumping from aircraft.

Future Significance

This study does recommend bringing back the glider. If however, the glider was reexamined as a strategic, tactical, or special operations airlift concept, lessons from this study will prevent the same mistakes made in 1944 from happening again.

In consideration of the cost of gliders, design-to-cost technology would assure cost effectiveness such as the $5,000 glider described in this study. In the era of composite material technology, low-observable stealth aircraft, and small suites of lightweight countermeasures equipment, the survivable glider is well within reach, but at what cost? The answer is in a design-to-cost approach that determines how many times a glider is used, and designing the glider with that number in mind.

For example, if a glider is used just once, why have a landing gear designed to withstand hundreds of uses as in a conventional aircraft? The Germans began to see this early in World War II when they studied what components of their gliders most frequently were broken in landings. They accordingly concentrated only on making those parts that failed the most. The Germans realized it was not cost effective to replace entire gliders when only the wheels broke on gliders under normal conditions.

A future glider could employ such concepts as discard-at-failure maintenance where a failed component is economically discarded. This

reduces costly spares, record keeping, high-skill maintenance and other costly functions associated with other aircraft. A no-adjustment design could also be used as a goal for a future glider. Such a design prevents the increased chance of error with each adjustment or maintenance action. Such goals would greatly reduce the capital cost of a glider. While a true expendable aircraft is probably beyond current technology, a cost effective glider is within reach. Several other concepts from this study are equally important.

As shown in the SUE comparisons, a glider is most cost effective when it provides some capability greater than the tug aircraft. The CG-4 glider could not carry the same number of troops as the C-47 aircraft, but it made up for this by carrying artillery, jeeps, and other valuable equipment not capable of delivery by the C-47. A future glider must provide more capability than available by existing aircraft.

One capability a future glider would provide is a low-cost method of delivering tanks to future contingency locations. The future glider could be designed to carry one or more armored vehicles and towed behind a C-5 or C-141 aircraft. Such gliders could theoretically glide to a landing zone from 2Ø miles or more.[2]

A question for the fielding of such a glider is who would sit at the controls? Both the Army and Air Force would have an interest in such a glider, but as a matter of doctrine, the Air Force should fly it. The Air Force pilots who fly this glider should be trained cargo pilots with the glider as an additional aircraft qualification. This is the most cost effective approach because the pilot could be employed as a tug pilot also. A possible alternative for transport gliders is remote

controlled flight for gliders carrying only tanks or other equipment. These could be flown from the cockpit of the tug aircraft.

Relationship to Previous Studies

A Model for success

The studies described in Chapter Two did not detail the elements of cost for a specific operation as this study does. The elements of cost in this study point out areas for improvement. These areas, if improved could have demonstrated the glider was more cost effective than the parachute. Although highly speculative, if the U.S. could have designed a glider with a capital cost of less than $5,ØØØ requiring almost no assembly, the glider echelon would have been cost effective as defined by this study. For example, if Table 5-1 for the 82nd Airborne's glider echelon is compared with a like table using a $5,ØØØ glider, the glider results as more cost effective as shown in Table 5-2.

Table 5-1.-- Cost per SUE(82nd Airborne 17 September 1944)

COST ELEMENT	GLIDER ECHELON	PARACHUTE ECHELON
Capital Cost per SUE	$12,859.80	$2,959.18
Training Cost per SUE	$442.66	$479.42
Assembly/Packing Cost per SUE	$79.60	$10.27
Recovery Cost per SUE	$11,831.10	$1,089.14
Crew/Parachute Pay per SUE	$1,751.71	$7,799.14
Total	$26,885.27	$12,326.88

Table 5-2.-- Glider Model for Cost Effectiveness(82nd Airborne)

COST ELEMENT	GLIDER ECHELON	PARACHUTE ECHELON
Capital Cost per SUE	$3320.05[a]	$2,959.18
Training Cost per SUE	$442.66	$479.42
Assembly-Packing Cost per SUE	$10.00	$10.27
Recovery Cost per SUE	$2888.44[b]	$1,089.14
Crew/Parachute Pay per S.U.E.	$1,751.71	$7,799.14
Total	$8402.86	$12,326.88

[a]Assumes a cost of $5,000 per glider using 50 gliders carrying 75.3 S.U.E.

[b]Using a recovery rate of 13 percent of the 50 gliders recovered, the remainder replaced at a cost of $5,000 each.

As the introduction to the glider equipment problem explained in Chapter One, the U.S. glider procurement program in World War II was not a well coordinated plan. The $5,000 glider however, was probably well within the reach of U.S. manufacture. By employing woodworking firms not involved in the war effort as the British did, and using less metal except in the nose and floor sections, a $5,000 cost might have been possible.

If the $5,000 glider had been delivered in a configuration suited for rapid, low-skill assembly it could have been assembled in less time than was used by the assembly lines employed in England. The glider mechanic's time could have been spent preparing the glider for flight instead of putting the pieces together. Another caveat for the glider program would have been to establish a number for the assault landings a glider could log before it was considered expended. As an example, eight major combat glider assaults were flown in World War II.[3] Using this figure plus two extra flights for training, the $5,000 glider could have had a service life of ten assaults.

A similar model for a cost effective glider can be constructed using the parachute echelon from the 101st Airborne on 17 September 1944. The 101st parachuted successfully 6,809 parachutists that day. For purposes of this study, assume that the CG-13, a forty-passenger glider, of which 81 were in Europe during Market, cost $11,000. The savings are not only in equipping costs, but the attendant savings in fewer glider pilots to train and overall fewer gliders to purchase.

Assume also that each glider has two rated glider pilots, and the recovery rate is fifty percent for the 171 gliders required to deliver the 6,809 parachutists the 101st parachuted in Market on 17 September 1944. This theoretical $11,000 glider also requires five men working five hours to assemble it.

Table 5--3. Cost to Deliver 6,809 by Parachute or Glider based on 101st Parachute Echelon in Market.

COST ELEMENT	6,809 Glider Troops	6,809 Parachutists
Equipping	$1,881,000	$1,968,192
Training	$113,482	$318,874
Assembly-Packing	4275 man-hours	6,834 man-hours
Paying	$883,260	$3,833,940
Recovery	$940,500	$724,556
TOTAL	$3,818,242 and 4275 man-hours	$6,845,562 and 6,834 man-hours

Note: Not included in the glider column are the 342 glider pilots who could increase the combat strength on the ground by 28.5 SUE if employed as infantry.

Although the model in Table 5-3 is a simple one assuming a $11,000 forty-place glider, it does demonstrate that cost effectiveness was possible is glider costs could have been reduced and recovery rates increased.

The limiting factor in using glider's for airborne assault was its cost effectiveness. The glider demonstrated it could land combat power--more combat power than the parachute, and land it quietly and accurately. The glider's cost and its low return on that cost prevented

it from being effective when compared to the parachute as a means for airborne assault.

What about future airborne assaults? Given that parachute assault will remain a capability of U.S. forces, does the glider concept offer any increase in capability today? The glider certainly does offer increased capability if cost effective issues such as the ones raised in this study are used as a measuring tool.

If a cost effective glider were developed, it would give true forced entry capability to all Army forces. No longer tied to the expense of parachute delivery, all Army divisions could conduct a forced entry in hostile territory. If the tank-carrying glider were perfected, it would give armor forces a reach not presently available. The glider offers other benefits as well.

In an era of long range missiles and chemical weapons being viewed as "poor-man's nukes" in reference to their lethality at less cost, the glider also has a role in this form of warfare as well. The glider could become a "poor-man's strategic airlift." The same components are present in the glider concept. The glider would offer greater capability at less cost allowing a poorer nation to possess greater airlift capability at a tactical and strategic level than available in present systems.

In cost alone, the glider if properly developed, could offer tremendous payoff to nations less capable of paying for expensive forms of aircraft, just as was done by the Germans after World War I.

Recommendations for Further Study

Strategic, tactical, and special operations use

Perhaps the glider could be brought back and could contribute to each of the three areas of airlift requirements. The three areas, strategic, tactical, and special operations, were all served by some type of glider use in World War II. For each of these areas, a future glider could possibly serve.

For strategic airlift, the glider could offer a cost effective airframe for moving tanks to contingency areas. The glider could be designed to carry a tank and equipment. This glider would not need to be used in an assault role, but could cheaply be towed behind C-5A and C-141B aircraft overseas.

In tactical airlift, prepositioned gliders could provide in-theater airlift for some troops and equipment at a considerable savings of having fleets of C-130 moved overseas. Of course, the tug aircraft still would need to arrive in-theater, but the glider could provide back-up tactical airlift.

If current doctrine assumes that the Army's only airborne division is the only unit providing a forced entry capability and that forced entry capability exists because of the parachute, then look at the cost of maintaining a parachute division. This study has already shown the huge costs of training, equipping, and paying the parachute force. At division level, this cost is significant, and the capability is only in one division. Perhaps gliders could give a forced entry capability to any division. Gliders could carry troops and equipment of any of the Army's

several light divisions on a forced entry mission, and probably with the same capability and less cost.

The most significant contribution a future glider could have is to the special operations forces. The units have a requirement for swift and silent entry into target areas. A well designed, cost effective the glider could serve as a stealth platform of significant capability.

In each of these areas, a feasibility study similar to the strategic airlift concepts study examined in Chapter One would serve to develop a future glider. This study should have cost effectiveness as its charter and stealth technology as its ultimate goal.

World War II glider-tug combinations

Another recommendation is the study a various glider-tug combinations employed in World War II. Various mixes of fighter aircraft and attachments for gliders would provide an revealing historical study.

Glider Pilot use

The glider pilot was the most interesting component of this study. The Army never had a clear idea of what his role, mission, and function was in combat. This author has interviewed several and was struck by the lack of guidance most glider units received. One thing is clear however, the World War II glider pilot was brave beyond measure and flew an expedient aircraft under demanding conditions. The glider pilot frequently fought in ground combat and many times his only reward was to strap himself in another glider bound for action. Although many authors have told his story, the glider pilot's ground combat role would provide an historical study of a particularly elite group of flyers.

Elements of Cost

What about the elements of cost used in this study? As a tool for the measurement of cost effectiveness, they are suitable for other assault systems as well as the glider and parachute. All five elements accurately measured the cost of glider and parachute assault while at the same time quantifying relative combat power by using the SUEs. What the SUEs and the five elements of cost provided was the benefit of coupling combat effectiveness with cost effectiveness. If the same amount of combat power is put on the ground by either a glider or parachute echelon, then the least expensive system is the recommended choice.

The elements of cost provided the mechanism for this decision. These same cost elements could apply to other assault systems as well.

Summary

This study has examined two methods of airborne assault, the glider and the parachute. These methods were compared to each other using a combat model. This model was the Market airborne operation conducted on 17 September 1944 by the First Allied Airborne Army into enemy territory in Holland during World War II.

Five elements of cost were selected as the yardstick to measure the effectiveness of the glider and parachute echelons as they were actually organized and employed in the airborne assault. From the perspective of these elements of cost, the glider fell short of the parachute as a cost effective assault system.

The major reasons for the glider not performing in the Market airborne laboratory as a cost effective system compared to the parachute was its high cost and low recovery rates. This resulted in the glider being a expensive piece of airborne equipment that required almost complete fleet replacement after each operation. Reasons for the glider's high cost were a scandalous procurement program and a poor early vision of its intended employment. The low recovery rates resulted from airborne planners failing to appreciate the utility of the glider as a reusable item of airborne equipment.

Several areas of comparison between glider and parachute employment in the this study are important for cost effectiveness. The British use of the X-type parachute and wooden gliders were effective. The huge costs of paying an airborne division surfaced in this study as well as the hidden costs of assembling gliders and packing parachutes to achieve a vertical assault capability. In summary, the glider as compared with the parachute in the first day of Market was not cost effective.

ENDNOTES

[1]Norman R. Augustine, Augustine's Laws, (New York: Penguin Books, 1986), 131.

[2]Edwin C. Parrish III, "Glider Delivery of the M1 Abrams," unpublished article submitted to Army magazine, 11.

[3]Doug Wilmer, "Glider Pilot" in USA Airborne Fiftieth Anniversary 1940-1990, (Paducah, KY: Turner Publishing Company, 1990), 386.

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